

HOW TO
Design and Build Your
Ideal
WOODSHOP
REVISED EDITION



Plans and ideas for turning your basement,
garage or outbuilding into a great shop



Bill Stankus

How to Design and Build Your *Ideal* WOODSHOP

REVISED EDITION



Bill Stankus

How to Design and Build Your Ideal Woodshop: Revised Edition.

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READ THIS IMPORTANT SAFETY NOTICE

To prevent accidents, keep safety in mind while you work. Use the safety guards installed on power equipment; they are for your protection. When working on power equipment, keep fingers away from saw blades, wear safety goggles to prevent injuries from flying wood chips and sawdust, wear headphones to protect your hearing, and consider installing a dust vacuum to reduce the amount of airborne sawdust in your woodshop. Don't wear loose clothing, such as neckties or shirts with loose sleeves, or jewelry, such as rings, necklaces or bracelets, when working on power equipment. Tie back long hair to prevent it from getting caught in your equipment. People who are sensitive to certain chemicals should check the chemical content of any product before using it. The authors and editors who compiled this book have tried to make the contents as accurate and correct as possible. Plans, illustrations, photographs and text have been carefully checked. All instructions, plans and projects should be carefully read, studied and understood before beginning construction. Due to the variability of local conditions, construction materials, skill levels, etc., neither the author nor Popular Woodworking Books assumes any responsibility for any accidents, injuries, damages or other losses incurred resulting from the material presented in this book. Prices listed for supplies and equipment were current at the time of publication, and are subject to change.

dedication

To Katherine, thank you for everything.

about the author

Bill Stankus has been woodworking for over 20 years. Before his love of woodworking took hold, he was an oceanographer and a fine-arts photographer. He has designed and built custom furniture and specialized in museum-quality restorations of antique furniture. He has taught woodworking at the university level, given seminars throughout the United States and consulted with major tool manufacturers. Bill is the author of magazine articles, video scripts, tool manuals and woodworking books. He currently resides with his wife and family in western Washington, and continues to work on his own ideal woodshop.

acknowledgements

Woodworking is many things: It can be a hobby, it can be repairing an old chair or making toys, it can be a craft or a business, it can be creating heirloom objects or simply puttering around in the woodshop. Wood and working are two average words that, when combined, create a fantastic venture. You (the woodworker) and your woodshop are the celebration of those two words.

This book isn't about picture-perfect workshops or snazzy photographs of tools. It is, however, an attempt to convey the following: Woodworking is an active process that combines desire, artistry, experience, problem solving, materials and effort. Making things with wood is truly one of mankind's ultimate achievements. And our quest for making wooden objects will probably never end.

There are a few individuals that I would like to thank for their contributions to this book. First, Alan Boardman was essential in clarifying the notion of the "ideal woodshop." He once told me that as long as he had a pocketknife and could whittle, he would be content. Sometimes saying the obvious simplifies the search.

I would also like to thank the following woodworkers for allowing me into their workshops and for the hours we spent talking about shops, lumber, tools and woodworking enjoyment:

Steve Balter, furniture maker

Earl Bartell, woodturner

Ted Bartholomew, woodturner

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David Beyl, instructor

Dave Buck, hobbyist

Derrick Burke, hobbyist

Charles Caswell, furniture maker

Harry Charowsky, hobbyist

Tom Dailey, hobbyist

Bob Folline, hobbyist

Steven Gray, woodwright

Robert Girdis, luthier

Hannes Hase, custom wood windows

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George Levin, furniture maker

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introduction



Just how are we to determine what is an ideal woodshop?

Old photographs and old line drawings can only show how historical woodshops looked. And modern-day woodshops are mostly seen via TV documentaries. There are almost no apprentice-ship woodshops existing that have a master craftsman passing on skills while at the same time producing objects for sale. Despite these limitations, most modern woodworkers seem to believe they have a grasp of what it takes to make an ideal woodshop.

Of course, each of us has a different starting point when setting up a woodshop. Some of us have shop training from art schools, trade schools or family heritages. There are those of us with tight budgets and those with unlimited funds for setting up a woodshop. A few lucky individuals might inherit tools from previous generations, while others spend a lifetime searching for their tools.

Many new woodworkers have been motivated by the Pied-Piper-like flood of PBS-type home-improvement programs, or by the amazing amount of woodworking magazines. Then, too, there is the siren song of manufacturers and tool catalogs.

Are there any connections amidst all this diversity? There certainly seem to be quite a few people interested in something. The proliferation of clubs, guilds and traveling roadshows all indicate that woodworking isn't a single-topic event with

an audience interested in “less is more.”

A recurring dichotomy seems based in stubbornness and passion. Old ideas and new stuff. Is there only one “right” way to achieve your goals? The flood of interest in the old ways has produced high-powered machines and intricate accessories for seemingly obscure uses. Does the mastery of 19th-century British woodworking really mean anything if you use a powerful compound miter saw or router? Certainly there is a background litany about good work, accuracy and organization, while at the same time there is a looseness to the definition of woodshop functionality. We use tools to make things: We seek the impersonal precision of milling machines and laser-like cuts in our craft, and yet we still use handheld tools. How many woodworkers feel that an imprecise joint is a failure? Are they obsessing over trivia rather than content?

It may be simplistic, but to design, build and set up your ideal woodshop requires a raft of diverse information — both historical and modern. You have to adapt every piece of the puzzle to your own situation.

I have never been that interested in electrical, plumbing or other construction skills, but I have had to cope with these elements in order to have a woodshop. More than 25 years ago, I began to build furniture. For many years, every moment produced new mysteries and more learning experiences. Even now, I don't have the so-called perfect woodshop. But I do enjoy working in the one I have — simply because I have tools and I can work in my shop to make things.

Learn from the past and adapt with the new. Question the pundits but realize the value of learned opinion. Don't build a woodshop only for the sake of building a picture-perfect shop. Take a lifetime to create your dream woodshop — and use it daily to make as many wonderful wooden objects as you can.

The reality is that the woodshop is a tool, and it is the craftsman's achievement to use that tool successfully.

In this new edition, there are many new photographs and each chapter has been revised. There is also a new chapter about the environment that you can create within your ideal woodshop.

chapter one

Building Safety Into Shop Design

BEFORE SETTING OUT TO DESIGN your ideal woodshop, safety should be foremost in your mind, since safety is a factor that has extraordinary consequences in both the present and future.

Is your woodshop a safe place? Think about this: Some of the most dangerous objects and materials that you will ever come across are in the woodshop. This includes just about everything that is used in the woodshop: machines, hand tools, solvents, wood and sawdust. The physical activity of lifting or moving heavy objects, breathing solvent fumes, touching various chemicals, listening to high-decibel sounds, holding vibrating electrical tools and climbing on stepladders are some of the obstacles that need to be safely managed. In fact, they are at the core of how you should design and build your woodshop.

There is a certain disconnect most beginners have regarding today's woodworking. Most beginners have never had years of instruction or the hands-on traditions of trade schools or apprenticeships. But let's assume that the beginner has the desire and abilities to set up a woodshop, and that person comes from some unrelated background: computer programming, business, sales and so on. Where does this beginner get the information necessary for woodworking? Most likely from books, magazines, videos and hardware store salespeople. But is that enough to really understand the relationships of the many facets of woodworking and safety? Does the beginner have the correct information necessary to judge appropriate products? Is the salesperson or magazine writer or video personality free of vested interests? Probably not. If the information is from a company, you can bet their legal and advertising departments have influenced their information. If the information is from a magazine or store, the information is potentially biased by advertiser or supplier influences. And, product review magazines rarely deal with the interrelationships of diverse products.

The essential question of safety is often obvious and also it is more than likely to be very subtle. Further-more, there are other complications to essential safety that historic woodworkers never dealt with: an array of plastics, man-made building materials, volatile liquids, environmental issues, building codes and regulations and so on. Today, it is not enough to know how to cut dovetails: Do you understand the complexities of mixing heat, chemical and dust fumes, synthetics, sharp things and electricity with flesh and blood?

It's possible that we could one day see the advent of safety inspectors for the home woodshop. Wood-workers, especially those with home woodshops, have had a long history of not being monitored by the agencies that scrutinize commercial woodshops. However, if you notice modern safety trends, there

probably are (or will be) people and organizations that want to codify what goes on in home woodshops. While there has been a trickling down of valuable safety products to the home woodshop, I can't imagine that many people want to have outside groups dictating home woodshop procedures and necessities. Having said that, most woodworkers are doing a good job of learning how to do woodworking, and they are generally buying tools and machinery that have been tested for safe use. Of course, there are many old, worn-out or poorly modified tools sold at garage sales or passed down through families. And these should be identified and gotten rid of so that accidents won't happen. However, in addition to operating machinery safely, we should also improve our handling of heavy materials (thus reducing bodily sprains and strains) and our use of chemicals (solvents and finishing products). More or less, the amateur woodworker and the one-person small-business woodshop want the best of two different worlds: the freedom of the hobby and craft world, and the tools, materials, techniques and business of the professional and commercial world. While this may seem fair if you are a home woodworker, the problem is that there are potentially unsafe woodshop situations not being corrected.

It is up to each of us to be individually responsible for having safe woodshops. Don't pretend that your woodshop is safe or that it's too expensive to do the right thing, or don't come up with some other rationalization that keeps you from upgrading questionable situations. Make your woodshop safe, learn proper woodworking techniques and never attempt to use tools or supplies in unsafe ways. Stay current on new tools, accessories and supplies. For example, router bits are now available in bright colors that are visible when the router is operating. Manufacturers often improve their products to comply with new safety guidelines. A few manufacturers actually make their products safer because of consumer demands.

SAFETY CHECKLIST

The initial steps toward woodshop safety begin with the idea that you have to be aware of your surroundings.

- Always look for the accident that's about to happen.
- Don't ignore potential accidents or dangerous conditions.
- Always evaluate the situation and ask yourself, "Is this the best way of doing something or is there a safer way?"
- If there's a potential safety problem, take the appropriate steps to correct it.
- Periodically review all woodshop safety considerations.
- If you have older machines, compare them to their modern counterpart's safety features.

General Safety Concerns

This list, though not definitive, is meant as a basic overview and a starting point for your own quest for a safe woodshop.

- Never work when you are tired.
- Never use tools and machinery when under the influence of alcohol, drugs or medications.
- Wear suitable work clothing that is not loose fitting or with floppy or dangling sleeves, ties, etc.
- Remove all jewelry, ties and scarves, and tie up long hair.
- Wear safety goggles or safety glasses that have side guards.
- Wear hearing protection when operating machinery and power tools.
- Have approved and fully charged fire extinguishers in the woodshop.
- Don't wear gloves while operating tools and machinery.
- Keep up-to-date insurance information on yourself, others using the woodshop and the woodshop itself. Check with your insurance company on policy coverage relating to accidents and other woodshop misfortunes.
- Keep a list of emergency telephone numbers near the telephone.
- Know where to go for emergency medical treatment.
- Stay current on codes, laws and other regulations pertaining to safety and hazardous materials, equipment and procedures.

Safety Preparation and Maintenance

- Read, understand and follow all instructions in the owner's manual for all machines and tools.
- Keep all owner's manuals in a handy location.
- Maintain all machines and tools to the manufacturer's recommendations.
- Use machine safety guards provided by the manufacturer.
- Don't modify safety guards or other safety-related equipment.
- Be sure that any modification to a tool or machine is either approved by

the manufacturer or within the design limits of the tool.

- Before adding any accessory to a tool or machine, be sure that it is both acceptable and safe.
- Use tools and machines for their intended purposes.
- Periodically review owner's manuals for safe operating procedures.
- Periodically inspect cutting tools, such as tungsten-carbide table saw blades and router bits, for damage or cracks. Replace as necessary.
- Keep cutting tools sharp.

Work Area Safety

- Do not work with a cluttered floor or with unstable piles of tools and materials.
- Wheels on mobile bases must be secured before using the machine.
- Prevent unauthorized use of the woodshop by installing lockable on/off switches on all machines.
- Have proper lighting and ventilation.
- Read and follow label information, including all warnings and cautions, prior to using solvents, finishing products or other chemicals, and follow all recommended use and safety procedures. If you have any concerns about products, call the manufacturer, your own physician or health agencies of the EPA.
- Not all rubber gloves are the same. Use the correct type when working with solvents, finishing products, paint strippers, etc.
- Never dispose of oily rags in sealed trash cans that will be exposed to heat or direct sunlight.
- Store solvents and other flammable materials in approved storage units.
- Never use flammable solvents or other flammable finishing products near water heaters or any other high-temperature device or open flame.

Equipment Safety

- Use vises, clamps or other safe holding devices to firmly hold work material.
- If you are considering buying used equipment, be very cautious about missing parts, modifications, wobbly shafts and belts, and any other

loose, damaged, bent or out-of-the norm condition. When possible, ask for owner's manual and parts list.

- Don't buy used air compressors. The problem is that you can't see rust and corrosion inside the air tank.
- Absolutely never consider buying an air compressor that has patched pinholes in the air tank.

Safety with Chemicals

I feel compelled to repeat myself: Read the labels on all finishing products and follow all recommended use and safety procedures. If you have any concerns about products, call the manufacturer, your own physician, health agencies or the EPA. Take no unnecessary risks relating to the handling and use of chemicals; design your woodshop to be user-friendly and safe.

Electrical Hazards Checklist

Make a copy of this list and check your woodshop for the following electrical hazards:

- _ Comply with local electrical codes concerning wiring type, conduits, hookups, service panels and other electrical features.
- _ Have the correct amperage and type fuses or circuit breakers installed in the electrical service.
- _ Light fixtures should have bulbs with the correct wattage.
- _ Halogen type lights generate considerable heat and should be kept away from accidental bumping and flammable materials.
- _ Electrical motors, power tools and machines should have their technical information plates attached.
- _ Electrical motors, power tools and machines should have labeling indicating that the product has been tested by a nationally recognized testing laboratory.
- _ Replace frayed or worn electrical cords.

- _ Replace electrical cords that have worn or bent plugs.
- _ Replace electrical cords nicked by sharp tools.
- _ There should be no standing water or moisture where electrical devices are used.
- _ Don't use unnecessary or overloaded extension cords.
- _ If extension cords are used, be sure to use correct wire gauge.
- _ Don't use modified adapter plugs: All three prongs should be intact.
- _ Don't use adapters that have a missing ground prong or grounding wire.
- _ Electrical cords shouldn't be placed in walkways or traffic areas.
- _ Don't have heavy objects resting on electrical cords.
- _ Electrical cords should be positioned well away from spinning or operating machinery.
- _ Unplug electrical cords when adjusting or performing maintenance on machines and power tools.
- _ Electrical cords shouldn't be fastened down with nails or staples.
- _ The woodshop should have a sufficient number of well-placed electrical receptacles.
- _ All outlets must work properly.
- _ Unused outlets should have safety covers placed in receptacle openings.
- _ GFI (ground fault circuit inter-rupters) outlets should be installed near sinks or other wet areas.

- _ Never use sparking electrical motors or tools near dust, oily rags or solvent fumes.
- _ Ventilation fans must be non-sparking and certified for ventilation of flammable fumes.
- _ There should be air circulation around electrical tools.
- _ Portable heaters must be listed as tested and approved for use in woodworking environments.
- _ Never use portable heaters near flammable materials such as rags, dust, scrap wood, finishing supplies, paper and drapes.
- _ Position approved portable heaters so that they can't be tipped over.
- _ Check for unnecessary machinery vibrations that can cause wear or stress on electrical wiring.
- _ Never leave woodburning tools, soldering irons, hot-glue guns, heat guns or other high temperature tools unattended, and unplug these tools immediately after using them.

Working with Hazardous Materials

- Read product labels and understand their implications.
- Have operational smoke detectors within the woodshop.
- Most vapors are invisible. And it is difficult to know how much vapor is too much. Ventilate the room.
- If the woodshop is located within a garage which has a gas water heater and parked automobiles, install a carbon monoxide detector and natural gas and propane gas detectors.
- If the woodshop is located in a garage or basement which has cracked concrete floors, then you should periodically use a radon detection kit.
- Have fully charged fire extinguishers rated ABC or BC and know how to properly use them. Consult with your local fire department for fire

extinguisher training classes.

- Do not pour water on chemical fires.
- Never mix ammonia with household bleach. The resulting solution produces a deadly gas.
- Use safety goggles, dust masks, multi-purpose respirators and rubber gloves.
- Be aware that standard clothing can retain vaporous fumes.
- Know the telephone number and location of a local Haz-Mat office.

FIRST AID

I have visited with manufacturers and their lawyers enough to realize that there are quite a few people who have gotten hurt by doing things that perhaps they shouldn't. A standard knowledge of first aid should be a priority for you, both in and out of the woodshop. But within the shop, you'll most likely face two types of trauma — cuts and electrical shock.

Treating Chemical Burns

Numerous solvents, oils, paint strippers, bleaches and dyes are dangerous, and their labels offer information regarding their uses and side effects. The following is the standard first aid procedure for treating chemical burns.

1. Immediately call for medical aid and rescue. If possible, tell the operator what kind of chemical has caused the burns.
2. As quickly as possible, flood the affected chemical burn area with water. Continue with the water for at least 15–30 minutes so that all traces of the chemical are removed.
3. If the chemical has gotten into the eyes, gently spray clean water into the eyes. If a water spray is unavailable, have the victim lay flat and then gently pour water into the eyes. Continue the eye washing for a minimum of 5 minutes.
4. Clothing can absorb spilled chemicals so remove

the victim's clothes.

5. If available, place a clean pad over the chemical burn area.

Making a First Aid Kit

To make a first aid kit, get yourself a sealed container, such as a tool box, and paint the red cross symbol on all sides so that it is easily identified by anyone. Remember to replace all supplies as they are used. Include the following:

- 5" × 8" card, preferably laminated, with street address and driving directions to the woodshop. This saves time when speaking with an emergency operator. This card should also include any medical conditions, such as diabetes, heart disease, allergies, reactions to medications and so on. Include name of personal physician.
- Box of assorted bandages
- 12 each 2" × 2" sterile pads
- 12 each 4" × 4" sterile pads
- 2 each 2" roller bandages
- 2 each 1" roller bandages
- Roll of 1" adhesive tape
- 6 each 3" to 6" wide elastic band-a-ges
- Scissors
- Tweezers, a nice version has an attached magnifying glass
- Safety pins

- Box of alcohol swabs
- Several pairs of latex gloves
- Antiseptic solution and wipes
- Eye goggles
- Resuscitation mask or face shield

Other useful items:

- Hand soap
- Flashlight
- Additional sterile or clean strips of cloth
- Plastic quart or liter bottle filled with water
- Survival blanket — it compacts to size of a fist, but will give warmth to shock victim
- Ice bag or chemical ice pack

Treating Severe Cuts and Bleeding

Steel is indifferent to flesh. Neither minor nor major cuts should be taken lightly. Severe bleeding can result in death. I suggest that, at the minimum, you read a first aid book and that the appropriate techniques for cut treatment are understood and practiced. I purchased a useful first aid book at a local community college titled *American Red Cross First Aid, Responding to Emergencies* by American Red Cross, Health and Safety Services (Mosby Lifeline 1996). I know from experience about the blink-of-the-eye speed in which accidents occur and about the trauma of bleeding cuts. Believe me, that is not the time to wonder “Gee, what do I do?” I still have all my fingers, but there are a few scars left over from unnecessary accidents.

Treating Electrical Shock

- Never put yourself in danger when considering the rescue of a person endangered by electrical current.
- If the victim is immobilized by live current, knock him free using a stout wooden implement.

- Monitor the victim's life signs.
- Have someone immediately call for medical support.
- Locate any burns where the electricity entered and exited the victim. These burns are often found at jewelry locations, belt buckles or where there was contact with the electrical wire.
- Treat entrance and exit burns as third-degree burns.
- The victim should be lying down and with the feet slightly raised.
- If the victim has no pulse, or the pulse is weak or irregular, a qualified person should administer CPR (cardiopulmonary resuscitation).
- If the victim is not breathing, or has uneven or very shallow breathing, administer artificial respiration.
- Keep the victim warm with blankets or jackets placed on top and under so that body heat loss is minimized.

Using Fire Extinguishers

Fire extinguishers give the appearance of something that is self-evident and as easy to use as “pull the trigger and spray.” The truth is, there is more to it than that, and I recommend that you read further about the use of fire extinguishers and talk with your local fire department about instructions in the proper use of fire extinguishers. Imagine this scene — a shop fire being spread further by incorrect use of a fire extinguisher.

Install fire extinguishers that have a gauge and use the PASS technique:

P— Pull the pin on the fire extinguisher.

A— Aim the fire extinguisher at the base of the fire.

S — Squeeze the handle of the fire extinguisher.

S — Sweep the fire extinguisher back and forth repeatedly to cover the base of the fire.

(From: Kidde Safety, Mebane, NC)

WOODSHOP SECURITY

I am not someone who wants to live in a bunker. But I also know we live in a tough world. Prudence is an important value, and it is wise to at least review your work area's current security. The following list also is an approach for reviewing the windows, doors, lighting and safety procedures of your woodshop.

Inexpensive Security Devices

- standard dead bolts
- dead bolts with attached alarmed rim; a battery-powered unit that will sound when the locked door is forced
- wide-angle door viewers
- keyed security bolt for sliding door
- any of a variety of window locks designed for different-style windows
- security bar for sliding doors and sliding windows
- metal lock reinforcers which fit on both sides of the doorknob and dead bolt areas
- a third hinge added to doors
- a rechargeable flashlight kept near a door or in an easy-access location
- for increased fire safety, lock sets can be installed to interconnect the doorknob mechanism with the dead bolt
- nightlights can be installed at appropriate outlets
- three-way wall switches can be installed so that lights can be turned on and off at the top and bottom of stairs or at opposite sides of a room
- telephones programmed with emergency numbers
- inventory your tools and accessories and keep a record of their models and serial numbers in a location other than in your woodshop
- have a proper insurance policy, including coverage for loss, accidents or disasters; ask your insurance agent about riders for additional coverage

Advanced Security Methods

- Replace basement windows with glass blocks. These will create a distorted image to anyone attempting to look in from the outside.

- Windows can be covered with a specialized security film that laminates glass with a tough transparent coating. This film resists penetration and will hold broken glass, more or less in place — a jagged window hole.
- There are many types of sophisticated alarm systems that can be customized for woodshops.
- Monitor the woodshop via closed-circuit TV. If you work alone and the woodshop is distant from the main living area, this allows a family member to periodically check that all is well.
- Install an intercom system for instant communication with remote areas.
- If you spend sufficient time working while it is dark, install sound- or motion-activated light switches.

Plants That Provide Security

Holly

Hawthorn

Rose

Barberry

Blackberry

Oregon Grape

Flowering Quince

Cactus

Yucca

Locust

Bougainvillea

Red Currant or Gooseberry

Exterior Security

Many security experts recommend using exterior devices and systems for home

security simply because they are meant to keep trouble from entering your house and woodshop.

There are far more choices than this list — these are meant to be suggestions of possible methods of securing your property.

- Install fencing around the grounds or yard. A minimum height of 40" is recommended.
- Do you like dogs? Dogs have keen hearing and are protective of their turf. They offer some protection against prowlers and thieves.
- If you don't own a dog, you can still install "Beware of Dog" signs or place a dog water bowl and resting pad outside on a porch or walkway.
- There are alarm systems that respond to motion detection with the sound of barking dogs. The sensors track any motion, and once the motion ceases, the barking stops.
- Have bright exterior lighting at doors, driveways and walkways. Place lighting on sides of buildings, on posts, under eaves or under windows.
- Motion detection lights will give visual warning that someone is outside.
- There are a variety of plants that have thorns or sharp leaves that can be planted under windows or near fences and walkways — consult your local nursery or garden center for plant hardiness in your climate zone (see "Plants That Provide Security" sidebar).

chapter two

The Woodshop Environment

WHY IS IT THAT WOODWORKERS — a group of people with great skills, wonderful problem-solving capabilities and powerful insights into all the world's problems — often set up woodshops that have exposed framing, creaky windows, no insulation, no ventilation or no heat? There is no reason for working in a cold, damp or stuffy woodshop. Want a cozy woodshop? Start by performing a woodshop energy evaluation.

- Is the attic well-ventilated?
- Is the attic insulation adequate?
- Is the wall insulation sufficient?
- Are the windows single or double pane?
- Are there storm doors?
- Are the windows caulked?
- Are the foundations caulked?
- Are heating ducts and hot water pipes insulated?

The uniformity of a well-insulated wall is interrupted by windows and doors; though necessary, they are the main cause of outside weather entering the woodshop. OK, that's obvious, but what may not be is that there are many new items available to keep your shop environmentally comfortable.

WINDOW GLASS

There are many types of glass and new types are constantly being manufactured. However, I would like to make note of just a few special types of glass: reflective, heat-absorbing and tinted.

Reflective Glass

There are several types of reflective glass, some of which do look like mirrors from the outside. However, for the woodshop, I'm only interested in the type that looks like normal window glass — and has insulating properties. High-performance reflective glass has a transparent film coating, sometimes only molecules thick, and it has unique insulation properties because of the unique

coating designed to reflect solar radiation, reduce heat transfer and still allow light into a room. Let's look at two types of high-performance reflective glass: Low-E and Heat Mirror.

Low-E (low emissivity) windows have two or more panes, a gas buffer, and a heat-reflective coating that helps keep the glass warm and can reduce energy loss by as much as 30% to 50%. Low-E windows also block about 75% of ultraviolet radiation from entering a room.



Rob Girdis' woodshop window with double-pane glass, wood frame and insulating blinds.

Heat Mirror glass has a reflective film which acts as a transparent insulation. It blocks about 99% of ultraviolet radiation (thus reducing the fading of interior items) and reduces noise levels by 50% — compared to a standard double-paned window. There are different types and styles of Heat Mirror glass. Manufacturers have claimed R-4 to R-7 insulation values for some of these windows.

There is a new generation of efficient windows just now showing up in the marketplace. Some are so new that only a few window installers are even aware of them. These new windows are being referred to as “superwindows.” They have very high thermal resistance because of multiple Low-E coatings, specialized gas fillings, reduced convective circulation of the gas fillings, and insulated frames. There are claims of R-8 to R-12 values for these windows.

Heat-Absorbing Glass

This glass contains metallic oxides which absorb solar energy, thus reducing heat gain. The absorbed sunlight is convected as heat to either the inside or the outside — depending on which side is cooler. This means that during the winter more heat is dissipated to the outside and during the summer more heat is dissipated to the cooler interior. While this may seem contrary to the cooling or warming of a room, there is still an overall benefit because substantially less heat-producing sunlight is admitted through heat-absorbing glass. Heat-absorbing glass reflects only a small percentage of visible light and therefore does not have the mirror-like appearance of reflective glass.

Tinted Glass

Color elements, such as bronze, gray, gold, green or blue are added to molten glass to create various tint colors. It can be made to either reduce light, absorb heat, or both. Tinted glass is most often used for indoor visual comfort or design purposes. Generally, it is not considered as an insulation type of glass.

Having the proper glass is only part of the insulation process. Window-frame material and illfitting window frames allow unwanted temperature or air into a room that will instantly reduce the energy savings of efficient glass. In fact, if the frame is temperature-conductive, the R-value can drop from R-4 to less than R-1.

tip

If you are investigating any window that has claims of a high R-value, ask if the stated value is for the entire glass surface plus the frame, or if it is only a center-of-the-glass R-value. Obviously, a high R-value for the combined glass and frame is preferred.

TYPES OF WINDOW FRAMES

Metal frames, usually aluminum, easily transmit outside temperatures to the inside and are often the cause of window condensation.

Vinyl frames have excellent resistance to heat loss and weathering. They are available in a limited color selection. For remodeling purposes, they are nearly impossible to repaint.

Wood frames offer excellent insulation but are susceptible to warping, shrinkage and wood rot. Wood frames also require maintenance with protective coats of paint or preservatives.

Fiberglass frames are fairly new but offer some of the best features sought for window construction. Fiberglass has excellent insulation properties and can be cut, sanded and painted. Some fiberglass frames are of solid thickness, and there are some that have hollow cores which may be empty air pockets or stuffed with

insulation.



One entire wall of this workshop has windows offering a wonderful view.

WEATHERSTRIPPING AND CAULKING

Windows and doors are breaks in the continuity of walls. Thus, they are significant sources of air and sound leakage.

Weatherstripping is the answer for the interface of a moving window or door. Factory-made windows and doors usually include weatherstripping.

However, if you are remodeling, you should choose the type of weatherstripping that meets your needs.

NONREINFORCED, SELF-ADHESIVE FOAM This is easy to apply on clean surfaces, good for the inside of door-jambs and window tops and sills. Some foams will hold moisture.

NONREINFORCED FELT This is nailed in place and can resist abrasion. Best used where not exposed to the weather.

REINFORCED VINYL, FELT AND FOAM This is reinforced with metal or plastic strips. Good for attaching to windows and doors.

SPRING STRIPS, S- OR V-SHAPED These are for window and door applications, can be either self-adhesive or nailed.

TUBULAR GASKETS These come in a variety of types, hollow or filled with foam, nailed to windows or doors.

DOOR AND GARAGE DOOR BOTTOMS (SHOES) There are numerous shapes and sizes of these. They are usually metal with tubular or rubber strips and are nailed in place.

WALL OUTLET SEALS These are specialized gasketlike shapes that conform to the wall outlet. Often fiberglass insulation is also stuffed around the wall box.

Other Methods for Maximizing Energy Efficiency

REFLECTIVE FILMS These are thin films, available in various-size rolls that can be applied to windows. They typically block more light than heat; however, they do slow the transmission of heat. Because they are very effective at blocking light, the inside room is darker than normal.

WINDOW TREATMENTS These are insulated window shades, shutters and blinds that will prevent heat loss through glass windows. Very applicable in an unheated woodshop during the night hours.

CAULKING EXTERIOR SEAMS There are many types to choose from, but silicon acrylic latex caulk is the better type for most applications. Expanding polyurethane foam, dispensed from an aerosol can, is useful for larger gaps and is ideal for air pockets around pipes and other irregular openings.

SOUND REDUCTION

To minimize noise from woodworking machines, you must interrupt the movement of sound. This is normally done by either reflection or absorption. Nonporous barriers are the principal methods of reflecting sound, and insulation materials are used to absorb sound. Combining both reflective and absorbing materials usually offers the best properties for sound reduction.

The main physical features you should review for reducing sound are walls, windows, doors and ceiling construction. If there are any holes or open spaces air can pass through, then so can sound.

Walls

Generally, the more solid a wall the more it will reflect sound. Concrete obviously offers the best in sound reduction. Since not all woodshops are in basements or have concrete walls, I will only discuss how to reduce sound in a framed room.

Most rooms are now sealed with drywall. Because the density of a layer is important, 5/8"-thick drywall is better than 1/2"-thick drywall for sound insulation. I know that there are many woodshops with open frame walls having no insulation, but it is the worse of possible sound controls. Since this is meant to be an overview, I will describe several methods for making walls more soundproof.

- Fill uninsulated walls with sound-absorbing batts, and cover with

drywall. A good example of this type is John Manville's ComfortTherm Sound Control Batts which are made of polywrapped, encapsulated, low-density 3½" thick fiberglass insulation. Standard insulation batts will also work.

- Attach a second layer of 5/8" drywall over the first layer of drywall. This method can be further improved by first attaching furring strips to the room side of the first layer of drywall and then attaching the second layer. This creates an air space that breaks sound wave movement through the wall.
- Stagger drywall seams so that a stud doesn't have more than one seam nailed to it.
- Some experts recommend using type X drywall as this second layer. Type X refers to the fact that the drywall is made to resist fire transmission through a wall for a certain time period. It is composed of gypsum and fiber-glass strands, making it ideal for sound reduction.
- There are complicated construction techniques involving building staggered wall studs. This advanced technique should be discussed with contractors specializing in building soundproof rooms. Your local library will also have books dealing with this technique.
- Stuff all open seams and holes with insulation materials. This is usually at the bottom and top of walls and around pipes.
- If there are electrical outlet boxes on both sides of a wall, offset them from each other.
- Caulk all seams and gaps. Remember the rule of thumb: If air can get through, so can sound.

Windows

- Single-pane windows easily transmit sound. Install double- (or triple-) pane windows, which are designed with an air pocket, to reduce sound transmission. Before purchasing new windows, check the specifications for their sound-reduction capabilities.
- Laminated glass sandwiches a soft vinyl-type layer between sheets of glass. It is made so that if the glass breaks, the shards are kept in place by the soft vinyl. However, the lamination also acts as a sound barrier and will reduce the transmission of shop noise to the outside.

Doors

Doors are difficult to soundproof, and it is also difficult to make doors as soundproof as the surrounding walls.

- Hollow-core doors easily transmit sound so they should be replaced with thick solid wood doors.
- High-quality weatherstripping should be installed around the door, even if it is an interior door. There are special acoustical door seals made for stopping sound.
- Music studios often have double doors. Imagine the cross section of a door frame: a solid door, an air space and another solid door. Both doors should have weather-stripping seals.

Ceilings

- If the ceiling has exposed joists, fill with insulation and then cover with drywall.
- Stuff insulation around light fixtures.
- If you have a drop-down ceiling with acoustic tiles, put insulation batts on top of the ceiling tiles.

HEATING THE WOODSHOP

Garages, basements and secondary buildings are often uninsulated and unheated. A warm woodshop is a pleasant place to be when the weather is wet and cold. For some, when there is no yard work or outdoor activity they go to the woodshop. Others are in the woodshop many hours a day because they have things to build. Either way, it is a wearisome task to warm a woodshop only by toil and sweat.

The Best Ways to Heat the Woodshop

FORCED AIR This is available in many shapes and sizes with the useful options of humidity control and air filtration. Gas- or oil-fired systems are very efficient, but space is needed for the duct work.

RADIANT HOT WATER Hot water is circulated via pumps through pipes into a radiator or under-floor tubing; no hot spots or open flame, except within the furnace boiler. Gas and electrical versions are available; an efficient system that is ideal when remodeling.

PASSIVE SOLAR Glass windows are positioned to absorb solar radiation. Best as supplemental source in colder climates, nice in milder climates. Carefully choose the correct glass.

HEAT PUMP This is efficient, but might require an expensive installation and may not be ideal in colder weather environments. It is better suited to areas needing more air conditioning than heating, since it does both. It also comes with air filtration and humidity control.

CERAMIC HEATER This is a portable, convection-style heater with a fan that blows air from a heated ceramic unit. It's reasonably safe, but has a slow response when changing temperature.

Other Possible Heaters

Reserve your judgment until reviewing the specific safety features of a particular heater model.

CONVECTION HEATER This is portable, and becomes very hot; keep away from flammables. Certain models can be used in woodshops. Available in baseboard and upright styles.

RADIANT HEATER This is also a portable heater. Use caution if it focuses heat in one direction; otherwise, it can warm quickly. A radiant heater has a high operating cost.

Not Recommended

WOOD STOVE This is expensive, requires frequent monitoring, has no thermostat, has large surface areas of hot metal, has open flame, can produce fumes within the room, takes up considerable floor/wall space, is messy with both ash and firewood debris, requires annual chimney inspection and cleaning, and releases outdoor air pollution. Check your local building codes before installing one in a woodshop. I have visited shops that have wood stoves as the primary heating source, but in each case the woodshop was not typical in size, use or location. Because there are so many variables related to wood stoves, I don't recommend them for the average woodshop.

LIQUID-FILLED HEATER This unit is filled with oil or water and looks like an old-fashioned radiator. These are often top-heavy and are not that efficient for woodshops.

KEROSENE HEATER This can be a source of carbon monoxide, and requires refilling with a liquid fuel. Keep away from flammables.

If you have concerns about a heater's ability to function in a woodshop environment, call the manufacturer for advice and recommendations. The reality is that heating systems often require customization in order to meet the needs of the woodshop and woodworker. It is advised that a heating-and-air master technician be consulted when designing and installing a heating system. Always check with your local safety and fire departments about what is permitted in your area.

RADON

Radon is not the home planet of a superhero. Instead, it's an invisible, tasteless and odorless naturally occurring radioactive gas formed by the breakdown of radium, a decay product of uranium, in the earth's rock and soil. All rocks contain

some uranium, although in most rocks it is a very small amount. Some rocks have higher than average amounts of uranium. This includes granite, dark shale, pitchblende, light-colored volcanic rocks, sedimentary rocks containing phosphate, and metamorphic rocks derived from these rocks.

Radon gas percolates upward through soil and rock and enters homes and woodshops through gaps and cracks in the building's foundation or through sump pump holes, drains, pipes and any other openings. Once radon gas has migrated into a closed room, it will remain there until it is vented out.

The surgeon general, the U.S. Environmental Protection Agency (EPA), the National Academy of Sciences and the American Medical Association have all identified indoor radon as a national health problem. The American Lung Association estimates that indoor radon exposure is the second leading cause of lung cancer in the United States. Radon effects are mostly long-term, and it apparently does not cause any short-term health effects, such as shortness of breath, coughing, headaches or fever. The EPA estimates that approximately one out of every 15 U.S. homes has indoor radon levels at or above the EPA's recommended levels.

So what's the big deal? What does radon have to do with woodworking? The answer is that most woodshops are located in homes, in basements, in garages or secondary ground level buildings. Most woodworkers spend hours in their woodshops and these woodshops generally are closed when there's work being done, so there is plenty of time for breathing radon.

The only way to know if radon is a problem in your home and woodshop is by measuring the actual levels. If your neighbors have had their homes tested, that is of no use to you. Rock and soil conditions vary and the percolating radon will follow the paths of least resistance to the surface. A single house with high radon levels can be surrounded by houses with low radon levels.

There are two types of testing: short-term and long-term. Short-term tests take from two to 90 days, and long-term tests take from 90 days to a year. Radon levels in a room also vary with the different seasons. The levels are generally higher in the winter months due to a larger differential between indoor and outdoor pressures. Also, houses are closed and less ventilated during the winter. The long-term test will give a better evaluation of average radon levels. Short-term tests are good indicators of whether additional testing is necessary.

Radon is measured in picocuries per liter of air (pCi/L). The EPA recommends that some sort of action be taken if radon levels are greater than 4 pCi/L. The average indoor level is 1.3 pCi/L and outside air is about 0.4 pCi/L. If your home or woodshop tests at values greater than 4 pCi/L, then you will have to find ways to lower that value.

Reduce radon to safe levels by filling in floor and foundation cracks, covering sump pump holes or venting the room to the outside. The process of subslab depressurization uses pipes and fans to remove radon gas from beneath concrete

floors and venting it outside. Once the modifications are in place, the room will need to be tested again.

If you are considering testing your home and woodshop, you can either purchase test kits or hire a service to perform the tests. Check in the telephone book yellow pages under "Radon," or call a local real estate office for the name of a certified testing company. You can also call the EPA at 1-800-557-2355 or the American Lung Association at 1-800-LUNG-USA for assistance.

This information about radon is from the Environmental Health Center, a division of the National Safety Council, Washington, D.C.

chapter *three*

Planning Your Ideal Woodshop

YOUR WOODSHOP WILL REFLECT your type of woodworking. Usually that means you're either a generalist or a specialist. Whether you are setting up a new woodshop or enhancing an existing shop, it is of utmost importance to maintain a realistic goal, similar to when buying or remodeling a house. Having expectations and making subsequent changes in design often result in unforeseen adventures.

There are several principles that motivate and drive the desire for a woodshop. First is wanting to build something. Second is having the finances to set up the woodshop. Third is having a location for the woodshop. What is often missing is having some background or experience that forges and shapes the generalizations we think are the foundations of woodworking. Unfortunately, many of us reinvent the wheel when we are attempting to design and set up a woodshop. Sometimes it's impossible to separate the wheat from the chaff when your own reference points are vague. And sometimes it's difficult to ask the right questions simply because you haven't learned the vocabulary. Consequently, we are often making do or working with the wrong equipment in an inappropriate space.

Many of us set up woodshops without a reference point, such as that provided by a trade school or a master craftsman. The advantage of not having had years of training from a master craftsman is being free to pick and choose everything from adzes to zebrawood — and using them for whatever seems appropriate. The disadvantage is that we don't have someone's hard-earned experiences to guide us. Being self-taught, we can't call upon traditions to specify project design or answer questions such as, “Should I buy a table saw or a band saw first?” And therein is the crux of the problem. How does one design and organize a woodshop? It's a tough question that, when answered, can lead one through the full spectrum from happiness to misery.

If you are fortunate, you will have friends with useful woodshop experiences and you will have ideas about what you want to do in a woodshop. Most areas have clubs or guilds that are a great resource center because their main purpose is advancing woodworking knowledge. Their members are motivated by an interest in woodworking and a desire to socialize with other woodworkers. While there are clubs which focus on general woodworking, there are also specialized clubs for carvers, lathe turners, model makers and other unique endeavors. Visit these clubs both for problem-solving information and for camaraderie.

FINDING THE PERFECT WOODSHOP

The thorny issue of using master woodworkers as sources of information must be addressed. There is no question that a skilled craftsman can inspire, motivate and

educate. I can think of no better person to go to for learning about cutting dovetail joints, applying lacquer, carving or lathe turning. These individuals have spent a lifetime learning the skills that most of us cherish. However, some caution is in order when looking at their woodshops. I would suggest that the woodshop of a seasoned craftsman or master woodworker is akin to a comfortable, but worn, pair of leather shoes, which fit only one person. Anyone else who tries to wear those shoes will get pinched toes, sore ankles or fallen arches. So, too, is the woodshop of the craftsman: The shop is an extension of that person. The layout, the equipment and the open space all reflect personal interests, habits and projects. Additionally, the temperament, rationalizations and judgments of a craftsman are imperfect. Even the masters have learned from a limited sampling of woodworking experiences. A person taught to use computer-controlled machines in a German trade school probably hasn't experienced the portability of a traditional Japanese craftsman's tool chest. Nor is the proponent of wooden planes necessarily interested in using an air gun nailer.

Setting aside the meticulousness of engineers and patternmakers, I don't know of any woodworker who approaches woodshop organization using the scientific method. Nor do I know of anyone using a consumer's research system or product review method to identify woodshop organization in a precise and controlled way. Instead, we organize in a facile and casual manner and let our pocketbook and free time steer us into tools, storage and gizmos. However, because we are spending our hardearned time and money, we should try to be somewhat methodical and logical when organizing the woodshop. Ignorance might be blissful, but it's not the best approach when organizing the woodshop.

The old expression "jack of all trades and master of none" does indeed apply to woodshop organization. Typically, the novice woodworker thinks that there is a particular set of tools and equipment that should be in any woodshop. The scenario develops something like, "I need a table saw, band saw, jointer, planer, drill press, router table or shaper, dust collector, air compressor, disc and belt sanders, workbench, tool chests, all portable power tools (including three routers) and every clamp known to mankind. After all," you say to yourself, "there must be a reason for a hundred different router jigs and templates being in the marketplace and don't the toolmakers and sellers know more about all of this than I do?" My advice is to show restraint and buy tools and equipment with caution and prudence. In fact, if you want to include a tool in your woodshop because it was used on a TV woodworking show or demonstrated at a woodworking seminar, be wary, that tool might have been shown simply as a sales and marketing ploy.

The media has also fostered the notion that there is a "perfect" woodshop complete with stationary and portable tools, uncluttered storage and room left over for the car, water skis and a winter's worth of firewood. There are so many references to the ideal positioning of equipment and workbenches, and the systematic flow of work from machine to machine, that it seems the goal is to have an efficient production business instead of a neat and useful woodshop. I have never seen a woodshop plan that matches my woodshop with regard to type of machines, size of workbench, available wall storage or family cooperation about not parking their bicycles in the shop. However, we do need to begin the

planning and organization of the woodshop with some type of personal perspective; otherwise, the woodshop might end up looking like a hardware store. There should be a reference back to the three guiding principles: woodworking inclination, money and space. Ask yourself these questions: "What do I want to build? What do I want to spend? Where will I do the work?"

TYPICAL WOODSHOPS

Some of the basic requirements for a woodshop are sufficient room size, machines, hand and power tools, workbench, lumber storage, tool storage, assembly area, dust collection, air circulation and ventilation and proper lighting. Each of these requirements has some application to all woodworking endeavors. How these requirements apply are a function of your woodworking interest. Tool storage, for example, is different for carvers and turners. And side lighting, although useful for carvers, isn't generally useful when making cabinets. One more thought before I outline the various types of woodworking and woodshop peculiarities: The majority of tools are designed for general-purpose use. Everything from band saws to mallets has to be reviewed as it applies to your needs.

The Cabinetmaker's Woodshop

If there is such a thing as a general-purpose woodshop, the furniture or cabinet woodshop might be it. Here is where we find the most general-purpose machines, tools and accessories. Why? Because furniture-making and cabinetmaking require basic cuts and joinery that are thought to be the domain of the basic power tool group (whatever that is). It's worth noting that tool and machine manufacturers rarely state that their products are designed for specific constructions. Their product information emphasizes the general nature or usefulness, accuracy or precision of nonspecific functions. That is because companies deliberately design these products for general use. The exceptions are the tools designed for a specific function, such as biscuit joiners or dovetail jigs. Generally, someone who has been building furniture or cabinets for years has a repetitive woodworking style and probably has a basic collection of tools to match that repetition. For example, I like to make table legs that have 1" × 2" round tenons that fit 1"-diameter through-mortises in the tabletop. To simplify cutting the round tenons, I made a jig out of plywood to use with a router. The set up is fast and easy and it takes very little time to make a set of legs. Consequently, I find it natural to design furniture using the round-tenon jig and I use it frequently. Thus, the woodshop becomes simplified through the process of repetition.

ROOM SIZE Furniture and cabinet work require a room that permits the safe operation of machines and other tools. There should be safe zones around machines such as table saws, so that the operator and anyone else in the woodshop can stand in an uncluttered and safe location while the machine is running. It is also necessary to allow enough space to move any workpiece to and from a machine without being obstructed. Yellow or orange safety tape stuck to the floor can be used to define this safety zone.

The furniture and cabinet shop should be large enough to accommodate typical machines, a workbench, storage cabinets and lumber storage. Mobile bases can be attached to machines so that they can be stored out of the way when not in use, but remember, even mobile machines require floor area for storage. Although a machine can be moved to create an open area, it still must be stored somewhere. Consider this point when arranging the work area.

An assembly area, or open space, is necessary for putting things together. Think of open space as an object, similar to a workbench or table saw. When designing your woodshop be certain to include enough room for assembling the largest piece of furniture to be built. Factor in the following: moving workpieces for assembly; access to, and positioning of bar clamps; flat and even flooring; and whether the workpiece can be left in this location while other tools or machines are used. Ideally, this open space should be away from stationary machines and near the workbench and clamp storage. And if the workpiece will have finishes applied at this location, the space should be away from any heat sources (e.g., water heaters, furnaces or sparking motors) to avoid fire danger.

LUMBER STORAGE Lumber storage is typically very low-tech in the furniture woodshop. The most common storage technique is to pile it on the floor or lean it against a wall. Lumber is heavy and, for safety reasons, shouldn't be stored at too great a height. If wall racks are used, care must be taken to build the racks sturdy and strong. There are several commercial wall racks suited for lumber storage. However, suitable storage can be made from 2×4 s at a fraction of the cost. A simple storage rack need be nothing more than an open frame structure. If you need to store short lengths, the structure can be shelved in with plywood or particleboard. Another simple lumber storage system consists of 2×4 s or 4×4 s vertically bolted to wall studs with sturdy dowels or metal rods inserted into holes. Remember not to place heavy loads at the ends of the dowels.

A very real option for the hobby woodworker is to let the lumberyard store the wood. Purchase what you need prior to starting a project. If the environment of your woodshop is significantly wetter, drier, hotter or colder than the lumberyard, purchase the lumber a month or so before you plan to start construction to allow the wood to acclimate to the woodshop. Small pieces of wood (good scrap pieces and cutoff pieces) usually are stored in boxes, bins and on shelves. I believe that there is a Murphy's Law concerning these pieces: "If they are left alone in a box on a shelf, their numbers will multiply and they will never go away!" Some woodworkers actually burn scrap wood in woodburning stoves.

MACHINERY Never before in the history of the world has there been such a variety of woodworking tools. It would take several football stadiums to display one of each machine model from all of the world's manufacturers. Today's woodworker can own an infinite combination of machines for making furniture. Selecting the machines that best satisfy your requirements is time-consuming and difficult. Most experts suggest the basic furniture-making machines: table saw, radial-arm saw, band saw, lathe, shaper/router table, drill press, jointer and planer. While this a predictable (and expensive) answer, there are other approaches for determining the machinery you need.

Keep in mind what you are planning to build, and avoid the notion that a general-purpose tool might be useful at a later date. Create a budget for machinery and set high and low dollar amounts. Next, visit with friends and acquaintances who enjoy woodworking. Ask questions about favorite machines, warranties, accuracy, maintenance, durability, accessories, spare parts and other concerns of this sort. Obtain specification and price sheets from manufacturers. Use caution when visiting retail stores selling machinery. Using the table saw as an example, no store is large enough to display all of the models from one manufacturer, let alone all of the table saws from all of the manufacturers. Most retail stores are going to attempt to sell you whatever is in stock — but the saw that they don't sell may be the perfect one for your needs.

Once you have a list of potential machines, add up the costs and look at your budget. But don't get discouraged and go out and buy a new truck instead. If the cost exceeds your budget, ask yourself, "Do I need that machine? Is there an alternate way to do the work? Can I use machines at the local school? What about combination machines? Hand tools?"

If you are a beginning furniture or cabinet maker, start with good quality and reasonably priced machines such as a contractor's 10" table saw, a 14" band saw, a 6" or 8" jointer and a portable 12" planer. Look for sale prices or buy used (but not worn-out) machines. Work with these machines for awhile until you understand their functions, foibles and how they apply to your own work. In time, as your skills improve, you can sell them (there's always a market for used machines) and move up to better or more specialized machines. If you have a limited budget, selling your older machine to buy a newer one is a great way to afford better tools.

Take your time when buying machines. There is nothing wrong with having a five- or ten-year plan. That is, use your machines, complement them with hand tools and plan for future purchases based upon your current woodworking interests. Perhaps a mortising machine or dovetail jig or wide-belt sander might suit your needs once you have spent time making furniture without them. Doing without is a wonderful woodworking process, because it allows you to problem solve and appreciate the real value of a woodworking machine.

HAND TOOLS AND POWER TOOLS Selecting hand tools and power tools requires the same process as that for machinery. The appealing nature and cost of these tools make them easier to purchase and store away. The problem is that, after reading a typical tool catalog, it seems that every tool is necessary for the woodshop. The reasonable thing to do is look at the construction process for your work and then decide whether a monster miter saw or battery-powered router is really necessary. The new home improvement centers (the modern version of hardware stores) are great for browsing and handling tools. It's important to touch hand tools and to experience their heft, balance and physical nature. But remember, don't buy a tool unless you need it — and need it for more than one work project.

WORKBENCH Furniture and cabinet makers require a workbench. Size, shape and number of vises are matters of personal taste. I know of woodworkers who use

their bench as a catch-all surface and others who treat the workbench as a piece of fine furniture. The workbench may be positioned against a wall or located so that it can be accessed from all four sides. The workbench should have the flattest reference surface in the woodshop so that it can also be used as a clamping surface. In my opinion, a traditional workbench is OK for building furniture with traditional hand tools, but if you are using routers, portable belt sanders and other modern tools, the workbench should be designed with those tools in mind.

TOOL STORAGE The shops of furniture and cabinet makers probably have the greatest array of tools, accessories, jigs and fixtures of any woodshop because this type of woodworking requires assorted layout and measuring tools, chisels, saws, sharpening equipment, mallets, hammers and accessories for all the power tools. Generally, these items are stored in chests or drawers. or are hung on walls.

Some potential furniture makers and cabinetmakers get distracted from their goal of making furniture and instead pursue the notion of the “perfect” woodshop: Drawers and cabinets are designed to store (or showcase) pristine tool collections. While there is nothing wrong with collecting, functional storage should be the goal if you plan to use the tools.

DUST COLLECTION Until recently, woodshops with piles of sawdust mounded around table saws and jointers were the norm. Heaps of chips were a sign that something was being made in the woodshop. Thankfully, times have changed. Furniture and cabinet shops can now be reasonably free of chips and dust because numerous types of dust collection units are available. The portable units take about the same amount of floor space as a band saw; built-in units can be as large as you want or need. Most dust collectors are affordable, so there is no reason to have potentially dangerous and unhealthy dust in the woodshop.

AIR CIRCULATION AND VENTILATION Woodshops need adequate air circulation. Windows, fans, open doors or any other system of venting the room to provide fresh air is a must. If the woodshop is located in a basement, humidity and lack of fresh air can rust tools and cause finishing products to set up poorly. And as the basement environment cycles between dry during the winter when the furnace is operating, and the warm humidity of summer, wood that is stored there will react accordingly. For example, drawers that work smoothly in the winter may swell with the summer's humidity and not open.

Another air-quality problem is radon radiation not dissipating due to poor air circulation. Radon is most commonly found when rooms are located over shale and the radiation seeps upward and into rooms through cracked floors and leaky foundations.

Fumes from finishing products and solvents, when confined to a closed room, are another potential hazard. Furthermore, many finishing products that evaporate into the air are flammable either as a liquid or as a vapor. Using flammable products in a closed room with a furnace or water heater or other heat source near by is a good way to end up with TV coverage of firemen hosing down the rubble of what was once your woodshop.

LIGHTING Ideal lighting should be glare-free, color-balanced and visually comfortable. If it were possible, I would like my woodshop to have every lighting source possible: windows, a skylight, incandescent lights and fluorescent lights. If windows and skylights aren't possible, the best artificial lighting is a combination of incandescent and daylight-balanced fluorescent lights. The fluorescent lights cover the overall woodshop, and incandescent lights enhance specific work areas (e.g., above the workbench and at machines).

The Carver's Workshop

ROOM SIZE Woodcarvers are very fortunate when it comes to choosing work areas, as the possibilities are almost unlimited. Carving tools can be packed up in a shoe box and taken to a vacation locale, so a seat under a palm tree becomes the workshop. Or woodcarvers can have beautiful state-of-the-art woodshops with room to carve old-fashioned circus wagons. But most woodcarvers work in modest-size shops in garages, spare bedrooms or basement corners. Compact work areas (50 to 100 square feet) are common.

MACHINES The diversity of woodcarving makes it difficult to generalize about the typical machines used. With that said, a modest-sized band saw, scroll saw, drill press and motorized grinding wheel (for sharpening) are the most commonly found machines. Woodcarvers do more rough shaping of wood than the precise type of cutting found in a cabinet shop. Also, carvers can work on thicker or smaller workpieces than are found in a furniture shop. If power rotary carving tools are to be used frequently, a small dust collector or shop vacuum should be included in the woodshop.

HAND TOOLS AND POWER TOOLS Woodcarving tools are generally either traditional chisels and mallets or power rotary tools. And rarely does a woodcarver use only one carving chisel. Generally, chisels are grouped as a complementary set (10mm No. 5 straight, 20mm No. 31 spoon, 12mm V-tool and so forth). Chisels are also long, short, stubby and microsize. Some are meant to be hand pushed; others are to be hit with a mallet. Rotary tools require AC, battery or air power. And there are hundreds of carving burrs and abrasive points from which to choose. What this means is that the carver's shop requires thoughtful storage for easy access to potentially hundreds of tools that vary in size from 1" to 18". Furthermore, there are mallets, sharpening tools, drill bits and assorted knives to use and store.

WORKBENCH One key requirement of a woodcarver's bench is that it must be capable of holding a workpiece rigid. When carving a statue, the workpiece is typically held vertically, and carving is done 360° around the piece. As work progresses, the workpiece needs to be moved so that work proceeds evenly around it. To do this, the workpiece must constantly be clamped, unclamped, repositioned and reclamped. Typical front and end vises are not designed for this type of holding. However, specially designed workpiece holders that mount directly to the workbench and can be rotated 360° are available for carvers.

Typically, woodcarvers use smaller benches than those of cabinetmakers. Some workbenches are about the same size as a bar stool. If using mallet and chisels,

the workbench must be heavy enough to absorb the constant vibrations from the mallet blows. Power carving also requires working 360° around the workpiece, but since it doesn't produce heavy mallet hits, it doesn't have to be as stout.

For smaller carving projects (that is, the bird-in-the-hand size), the workbench probably will be used as a place to rest tools while working. A TV tray is actually adequate for small carving work. If you are sitting down, it's large enough to hold a few tools and catch the workpiece chips.

For carvers, the workbench is the assembly area. Carved workpieces are not usually the size of furniture, so a separate area is not required.

WOOD STORAGE I haven't seen many woodcarvers' woodshops that have racks of long lumber. Instead, woodcarvers tend to have boxes and bins of small wood pieces: cutoff pieces, firewood-size chunks, limbs and slabs of wood. Generally, the reasons for racking lumber (flatness, moisture control, etc.) aren't as necessary for woodcarving. Shelves and bins are perfectly acceptable for storing woodcarving wood.

TOOL STORAGE The woodcarvers I have known all have had a similar work environment in one respect: Their work area is like that of a piano player; that is, most of their tools are within easy reach when sitting or standing at the workbench. Consequently, tool chests with plenty of small drawers, tool racks behind the workbench or even coffee cans filled with tools sitting on the workbench are common types of storage. Power carving tools are generally suspended over the workbench or hung on a nail next to the bench, and the grinder for sharpening is equally close at hand.

DUST COLLECTION It's difficult to remove wood chips while carving. The old expression "let the chips fall where they may" still applies. The great thing about using a mallet, chisels and knives is that the chips do fall to the floor and you aren't breathing dust. However, when using power tools, the dust flies through the air and into faces and lungs. It's not uncommon to watch a power carver, using a rotary tool, doing detail work fairly close to the face. Obviously, safety goggles and dust masks should be used, but a dust collector for drawing the dust away from the work area would be ideal.

AIR CIRCULATION AND VENTILATION Several conditions make air circulation and ventilation very important. Paints and other finishing products should be used in a well-ventilated area. Again, many finishing products are potential fire hazards. But even if the finishing products are not flammable, it's best to vent the room so that you (and others) don't have to breathe the chemical fumes. Carvers also enjoy working with unusual and exotic woods, like applewood or cocobolo, that can cause skin irritation, so efforts should be made to work as cleanly as possible.

LIGHTING Since most carving work is done in centralized areas, fewer lighting fixtures are needed than in a cabinet shop. Ideally, the carver's shop should have both incandescent and fluorescent overhead lighting with separate on/off switches. Side light is very useful for the carver. By turning off the overhead

lights and using side lighting from a tabletop gooseneck lamp or other type of lamp, the workpiece will have different shadows which helps to visually reveal textures.

The Lathe Turner's Woodshop

Woodturning is aptly named, because every time you turn around there are new lathe and tool innovations and new lathe techniques. The past 20 years have seen incredible developments in woodturning — new lathe designs for turning bowls, spindles and miniatures, new shapes in turning tools and an armada of workpiece-holding devices — and to make it even better, a new generation of woodturning instructors, instructional videos, magazines and woodturner's clubs as sources of information.



Hobbyist John MacKenzie enjoys lathe turning and having a large air compressor.

ROOM SIZE The basic lathe turner's woodshop can be compact, with enough room for a lathe, other tools, machines and storage. The basic nature of woodturning allows the work project to be started and finished on the lathe, which means there is little need for additional room space for other types of wood processing. Because the lathe is usually located against a wall, with the operator in a more or less static position, the woodturner can easily set up a woodshop in a garage or basement.

MACHINES The traditional wood lathe has undergone considerable design changes because of the heightened interest in bowl turning. In the old days, lathes had long beds with 36" to 48" distances between centers and were mostly used for turning stair spindles and other long pieces. These lathes generally had a 6" distance from centers to bed surface which meant that a 12" bowl was the

maximum capacity over the bed. Bowls of greater size were meant to be turned “outboard” on the opposite side of the head stock, if the lathe had that capacity. Today's turners often use both the head and tail stock for support while turning bowls. That means that the distance from centers to bed should be adequate to turn larger diameter bowls. Many lathes now have this capacity and other useful features, such as DC motors, which permit variable turning speeds starting at zero RPM. AC motor variable speeds usually begin at about 500 RPM.

Other machines common to woodturner's woodshops are band saws, dust collectors and grinders. Table saws, jointers and planers can be useful for wood preparation, but they aren't a necessity.

HAND TOOL AND POWER TOOLS There are many tools and accessories that aid in woodturning. A few of the more important power tools are a cordless drill for attaching face plates, a finish sander for sanding the workpiece while it's still mounted on the lathe, a rotary tool for detail work and sanding, and a jigsaw or saber saw for preliminary shaping. There are many useful measuring devices, such as inside and outside calipers and center finders. If hand tools are used, it's probably for preliminary wood removal or for some detail design work.

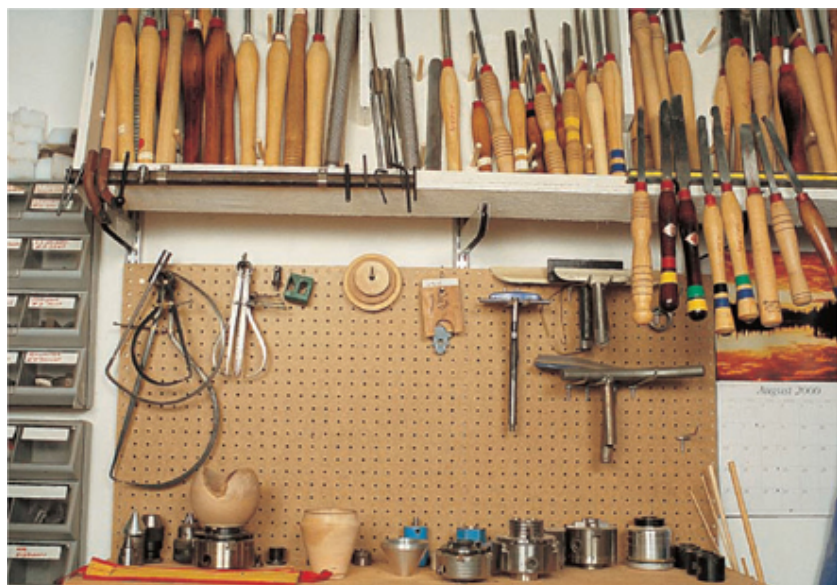
WORKBENCH In a sense, the lathe is the workbench. Once the preliminary shaping of the workpiece is done, just about everything else is done at the lathe. The other ongoing activity while turning is sharpening. For convenience, most turners install a grinder next to the lathe. A small workbench or countertop is useful for the odds and ends of setup or takedown work. The workbench is also used for sorting wood and other miscellaneous tasks.

LUMBER STORAGE Depending upon your zealousness, storing wood can range from a few pieces to filling garages, decks and barns with chunks of wood. If you are collecting wood and searching for downed trees in orchards, yards, parks and forests, you will need adequate storage. Not only will you need room to store the freshly cut (often referred to as *green* or *wet*) wood, but you will also need storage areas for the drier pieces. To further complicate the picture, there should be a functional inventory system so that different species can be identified — without leaves, one chunk of wood is difficult to tell from another.

TOOL STORAGE Lathe turning, billiards and golf have one thing in common: They all require easy access to long, thin tools. Neat and tidy storage for lathe tools is indeed similar to racks designed to hold cues. But don't make a rack for 12 tools and then buy 13. One possibility is to make a wall rack that can accommodate a growing tool collection. Another easy storage solution is pegboard-covered walls near the lathe. A roll-around cart also permits easy access to lathe tools, and it's less limited in the number of tools it can hold.



Earl Bartell keeps a small take-apart table near his lathe. The table has rows of holes around its perimeter for holding lathe tools. The type of tool is identified by different colors and numbers of rings on the handles. The table is assembled with oversize knobs for quick assembly. He also uses this table when teaching lathe classes at locations other than his woodshop.



Also in Earl Bartell's shop is this oversized shelf and wall pegboard, located near the lathe. Frequently used chucks, tools and other accessories are within arm's reach of the lathe.



Earl Bartell uses an auxiliary tray mounted to the lathe bed for frequently used tools. The tray is easily repositioned or removed when necessary.

ASSEMBLY AREA The assembly or construction area is at the lathe itself. Off-lathe work consists of activities such as tool sharpening, wood preparation and detailing and finishing work.

DUST COLLECTION Depending on whether dry or wet wood is turned, the debris will come off the turning as long stringy pieces or as smaller bits and dust. A good dust collection system will not only make the lathe work neater and easier, but also keep the debris from traveling many feet away from the lathe. Without dust collection, the debris field (especially that of green or wet wood) looks like a confetti celebration — of carrot peelings. Ideally, a dust collection port should be positioned behind and near the turning area. Articulated ductwork with a port is especially useful when it can be repositioned for any work angle or location. In truth, most turners will let wet wood peelings pile up on the floor because their

dust collectors cannot handle the volume and weight of the debris. If a duct port is positioned at the lathe it is for dust control.

AIR CIRCULATION AND VENTILATION Moving dust and chips away from the work area also means cleaner air for the lathe operator. A simple solution is to position an electric fan near the work, so that it moves air (and dust) away from the operator, preferably toward a window or door.

Many turners use helmets with face guards that have built-in fans and filters. These battery-powered units filter air at the back of the helmet and move clean air across the face area.

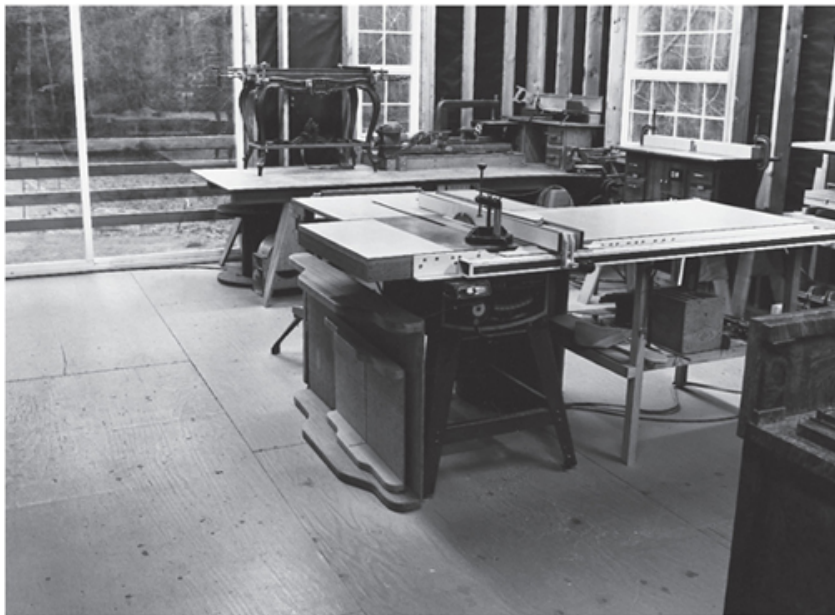
LIGHTING Pleasant overhead lighting is a necessity in the wood turner's shop. It's advantageous to be able to turn different lights on and off so that wood surface textures and features can be easily viewed from different lighting angles. Isolated spotlights aimed at the work area are also useful for watching how cutting tools perform against wood.

The Furniture Restorer's Woodshop

Furniture restoration and repair woodshops have to be more versatile than the typical furniture-making, lathe turning or carving shops. That's because the restorer has to be able to set up the woodshop so that almost every woodworking skill can be performed. For example, replacement chair rungs must be turned on a lathe, broken decorations must be carved, or drawer sides and bottoms must be cut to a specific size and thickness. Even if you specialize in one particular item (chairs), it's difficult to know what demands the next broken piece will make on the woodshop.

ROOM SIZE The type of furniture being restored determines the necessary size of the room. For example, a dining room obviously requires more space than an antique jewelry box; a drop-front desk requires more space than a hall mirror.

The woodshop has to have enough room for three functions: storage of broken pieces, space to fabricate replacement pieces using tools and machines in a woodshop filled with workpieces, and finally, space for cleaning, disassembly, gluing up and reassembly. I spent many years restoring turn-of-the-century Arts and Crafts (mission-style) furniture, and the sizes of those pieces was always a problem. Sideboards and settles (benches) are large, heavy and difficult to move. If several pieces were brought into my woodshop, suddenly the room got smaller. So plan enough space to store works-in-progress as well the machines to work on them.



Here's a view of Doug Matthews' woodshop. The sliding glass doors are often left open in good weather.

MACHINES Unlike furniture and cabinet shops where machines are required for a significant portion of the construction process, the same machines are minimally used for restoration. The chair or table is already made, it just needs a part or two. The emphasis thus shifts to the need for high-quality machines to make occasional replacement parts. If I could assign a proportional value to the need for machines in restoration work, I would say that need is less significant than other factors. Far more important is understanding how to use various joinery techniques, using chemicals or gluing up odd-shaped pieces.

You may use a lathe to make bowls (for your own enjoyment), but very rarely do you need a lathe to restore bowls. Instead, the restorer's lathe will be used to turn replacement spindles, posts and rungs, so its main feature should be bed length (distance between centers).

A high-quality saw blade is the most important feature of a table saw for restoration work, because it's often necessary to make tear-out-free and odd-angle cuts through antique wood. The aim is to waste as little as possible of the irreplaceable original wood. Band saws should have 1/8" or 1/4" smooth cutting blades so that clean radius cuts can be made easily.

The same kind of careful evaluation should be applied to other machines as well. For example, a planer with a slow feed rate is preferred for planing highly figured wood.

HAND TOOLS AND POWER TOOLS I firmly believe that successful restoration work requires the use of an array of traditional hand tools and power tools. For example, a desk or cabinet from the early 1800s probably was built with hand-cut dovetails. If the piece has boards that are damaged beyond repair, the replacement wood will need hand-cut dovetails made to match the original. That means using a tenon saw, chisels, a marking gauge and a mallet. Or there may be hardened glue in a dowel hole that resists being picked out. Using a rotary tool with a round burr might be the only method of removing the dried glue.

The tool selection for restoration work is eclectic due the variety of potential repairs. Bench planes, moulding planes, routers with specialty cutters, scrapers, chisels, wire brushes, screw extractors, band clamps and putty knives are but a few of the tools that make work easier.

WORKBENCH The traditional workbench with front and shoulder vises is useful to the restorer simply because that prized antique now being restored was originally built at such a bench. And duplicating the original construction process will lead to a better and more valuable restoration. However, if you have the room, a low workbench (approximately 12" to 24" high) is also very useful. A 4' × 8' sheet of $\frac{3}{4}$ " particle board laminated with melamine resting on low sawhorses is ideal for general cleaning and disassembly. Melamine cleans easily, resists most glues and can be turned over for another clean side if it becomes scratched.

LUMBER STORAGE Just what is the lumber in a restoration woodshop? I like to have bins of wood pieces sorted by color — dark, light, reds and tans — so that colors can be quickly matched with the workpiece. And I have storage for pieces from discarded furniture and other devices. I once had to replace a spindle in a Windsor chair that dated to approximately 1795. I searched for months to find a piece of ash that had a similar color and grain pattern. My search ended when I found an old garden rake handle that was a perfect match. Now I save all sorts of wood simply because I never know when it will be useful. I also like to keep veneer pieces stored between plywood covers, an arrangement resembling a scrapbook. Full rolls of veneer should be kept rolled and wrapped in paper to keep it clean and out of the woodshop air.

FINISHING PRODUCTS AND STORAGE Don't be casual about storing finishing materials, finishing products and solvents. Specialized metal cabinets for storing hazardous and flammable materials are available, and there are specialized trash cans for oily rags and other flammable products. Check in the telephone yellow pages under "safety equipment" for a source of storage cabinets. All finishing materials and products should be stored a safe distance away from any heat source or direct, all-day exposure to sunlight. Finally, keep all finishing supplies away from those who aren't trained in their usage.

AIR CIRCULATION AND VENTILATION If you have done any paint stripping or furniture repair, the words methylene chloride should speak volumes to you. Also, lacquer thinner, paint thinner, benzene, MEK, alcohol, turpentine and wood bleach are all dangerous and should be handled with extreme care. Since the earliest days of the industrial revolution, chemicals have been both a blessing and disaster to man.

The phrase “mad as a hatter” referred to those who made hats with poisonous chemicals. The early-day photographers worked with their faces directly over mercurycoated glass plates while developing film plates. These photographers didn't live long; old-time restorers who worked for long periods breathing formaldehyde and other toxic chemicals didn't live to ripe old age either. If having a long and healthy life is important to you, avoid chemical risks and work with intelligence and caution. Know the chemicals that you are using and follow all product safety notices. Store and use all finishing products as if they were the most dangerous liquids in the house (they probably are). Think of your skin and clothes as if they are sponges, ready to absorb any oil, solvent, bleach, dye or stain. Build and set up the woodshop with whatever it takes to be safe.

LIGHTING Restoration work should be done with proper lighting. Ideally, the lighting should be color balanced to simulate the room where the repaired piece will eventually reside in. It is worth asking the question about the room light before starting on any repair/restoration projects. Since there are a variety of different color-balanced fluorescent lights, keep a supply of these available. The lighting tubes can then be replaced according to need.

Restoration work also benefits from side lighting. That is, a strong light source angled from a horizontal location will cast shadows on the work area. These shadows that are created will enhance the wood grain and carved surfaces, and therefore make detailing the work easier.

Commonly Found Woodshop Mistakes

- Floor clutter
- Poor ventilation & poor air circulation
- Poor dust collection design, including collector size, type of pipe and pipe configuration
- Improper storage and handling of volatile and hazardous materials
- No provision for chemical spills
- No provision for disposal of unwanted hazardous materials
- Heavy lumber stored at too great of height
- Removal of safety guards from machines

- Ignoring appropriate use of hearing and eye protection
- No first aid supplies or fire extinguisher
- No contingencies for accidents or emergencies
- Not reading operator's manuals
- Poor quality lighting
- Insufficient electrical supply
- Insufficient number of electrical outlets
- Reliance on electrical extension cords
- Space is too small for the number of machines, benches, etc.
- Little or no open space
- Poor access for moving large and heavy objects into woodshop
- Unrestricted humidity, especially in basement and garage woodshops
- Far too much reliance on the concept of “assuming,” as in, “I assumed that it was OK.”

chapter four

Choosing the Right Shop Location

THE IDEAL WOODSHOP LOCATION is the location that you already have. If I could make a wish, like most woodworkers, I would have a separate building with 2,000 square feet, high ceilings, skylights, one or two windows with views of rivers and mountains, an oversize door (maybe even a garage door), wood flooring, heating and air conditioning, plumbing with sinks and a toilet, sound-insulated walls and a smaller secondary room for office needs and for displaying the things I've made.



This is the view from my woodshop. I am surrounded by a forest of Douglas fir, Western red cedar and hemlock trees.

Setting wishes aside, I know that I do have a woodshop for woodworking. And that is perhaps the the most important reality. In fact, this realization should always be the main consideration in the quest for the ideal woodshop. If you have a location or space that is usable, ask yourself which is more important — the woodshop or the things that you make? It's easy to be distracted by pinup pictures of fancy or well-appointed woodshops. What is more difficult to see in the coffee-table woodshop book pictures is that the ideal woodshop is really nothing more than the woodshop that is your own, where you can happily practice your woodworking. You can always improve on fixtures, storage and so on, but those things can evolve as you do your woodworking.

Most of us use the garage or basement for our woodshops. Sometimes, if we are doing less messy work, we might be able to use a second bedroom or part of the

laundry room, but the rooms with the most space for a shop are garages and basements. However, organizing a garage or basement is not necessarily a simple task. Garages are storage tunnels, and basements are storage holes. Room proportions and construction materials differ, and the use of either room means displacing specific home utility functions.

THE GARAGE SHOP

Typically, garages are for one or two cars; this translates into approximately 10' \times 20' (200 square feet) for one car and about 20' \times 20' (400 square feet) for two cars. Garages usually have a garage door, a door into the house and a window. They can also have wall-mounted cabinets, a water heater, a built-in vacuum system for the house, a laundry and overhead storage in attic or open rafters. Garages in newer houses are generally framed but can also be constructed of concrete blocks or brick.

Let me create a hypothetical garage for the sake of solving a space-utilization problem and designing a woodshop. Imagine a two-car garage in which cars are parked at night. In addition, the garage is also used to store bicycles, sports equipment and garden tools. It has one window on a side wall, a door into the house and a door to the outside. Other noteworthy features include open rafters, one 4' \times 5' wallhung cabinet, the house electrical service panel, one overhead light and AC outlets on three walls.



Jon Magill converted his garage into a woodshop, and two of the car bays are used for woodworking. When the cars are parked outside, mobile machines and portable workstations are

moved into their locations. There is ample open area for most construction projects.

Because the car is destined to remain in the garage for a certain number of hours each day, only the walls and the overhead areas can be used for permanent storage. These storage areas will determine the actual design and composition of the woodshop. Remember, even though the car will be outside when machines are placed in the open central area, all equipment must be returned to the wall areas or ceiling when the car is parked inside.



This woodshop is permanently set up in a garage. Note the skylights, indirect lights, air filtration box and the location of the workbench relative to the permanent wall with the storage/countertop area.

Begin by making a list of all permanent storage: household items, sports equipment and so on. Next, make a list of woodworking machines, tools and supplies that you own and also a list of things you plan on acquiring. Now, using $\frac{1}{4}$ " graph paper, draw a floor plan of the garage, including doors, windows and steps (use $\frac{1}{4}$ " $3/8$ 1'). On a separate sheet of graph paper, using the same scale, draw all machines, cabinets and storage containers that you want in the woodshop (or use the icons found on the next page). Cut these drawings out, and place them on the graphed drawing of your garage floorplan to experiment with spatial arrangement, as shown on page 32.

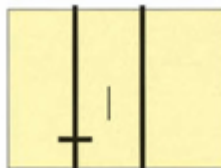


Table Saw

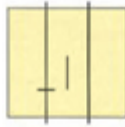
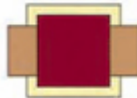


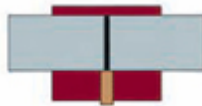
Table Saw



Planer



Planer



Jointer/Planer



Radial-Arm Saw and Extension Tables



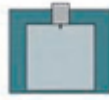
Lathe



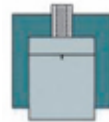
Jointer



Band Saw



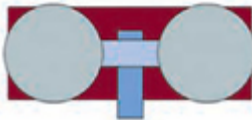
Joinery Machine



Joinery Machine



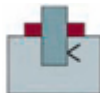
Air Compressor



Dust Collector



Disc Sander



Drill Press



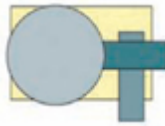
Scroll Saw



Chop Saw



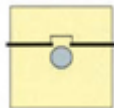
Shop Vacuum



Dust Collector



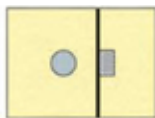
Drum Sander



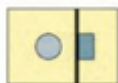
Shaper



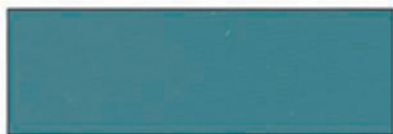
Shaper



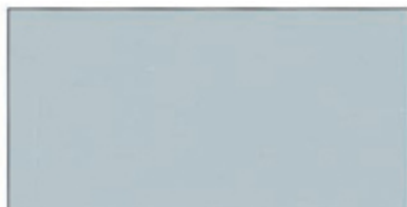
Router Table



Router Table



Workbenches



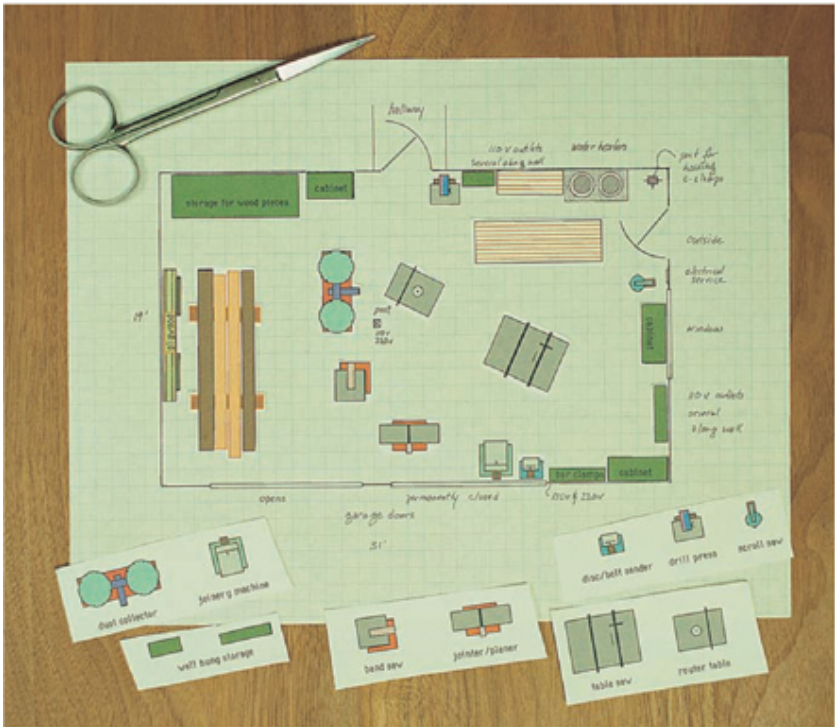
4' × 8' Sheet Stock



6' × 8' Lumber

Scale $\frac{1}{4}" = \frac{3}{8}'$. Use $\frac{1}{4}"$ grid paper and copies of these icons to create woodshop

layout arrangements.



Use the icons on page 31 and lay out your shop on 1/4" grid paper.

Typical Dimensions and Areas

- Workbench (18' x 15')
- Household storage
- Sports equipment
- Garden tools
- Wood cabinet #1
- Wood cabinet #2
- Workbench
- Table saw
- Band saw
- Drill press
- Router
- Planer
- Dust collector
- Workbench storage

The results of your graphing might look something like what you see above. Use the chart on this page as a quick reference for typical dimensions and areas of woodshop tools and other items.

Now, if you were to place all the items listed in the chart at left, you would have 211 sq. ft. of tools and other objects. But the garage has only 200 sq. ft. of space. Obviously, there is less area available than the floor area required when the car is inside. Judicious wall and overhead storage is necessary to open up the woodshop area. So begin by rethinking the common ideas of storage. Consider ripping out the garage cabinet furnished by the house builders. Don't anticipate using secondhand bookcases, old kitchen cabinets, inexpensive metal shelvings or any other combination of odds and ends, and resist the urge to build new cabinets and storage units until you are reasonably certain of your needs and requirements. Sacrifice all of these things in the name of efficiency. In fact, the best approach might be to develop an overall plan that unifies the entire room using a design that incorporates both house and woodshop items. This plan might include floor-to-ceiling storage units near the garage door consisting of broom-type cabinets for storing rakes and shovels, with compartments for flower pots, located beside cabinets for storing skis and tennis rackets with drawers for storing camping supplies. Similar built-in units could be used for tools and supplies. Specialized features would allow for a lumber rack, a workbench and a clamp rack. Add mobile bases to your machines so they can be stored against the walls and easily moved to the center area when the car is parked outside. This unified design might even create enough open space so that some work (not machine work) can be done at the workbench even when the car is inside. Once there is a workable layout, the details of flooring, wall insulation, electrical service, lighting, ventilation and security can be addressed.

Flooring

If the garage floor is cracked, rough or oil-stained, it should be cleaned, repaired or reconditioned before any other remodeling. Cracked or rough concrete floors make it difficult to move machines and construction projects. Casters are generally too small to roll over wide cracks and mobile bases may not work well on rough or uneven floors. Engine-oil stains, besides being ugly, will contaminate wood and shoes.

There are several options for restoring, repairing or resurfacing concrete floors.

- Remove oil and grease stains with liquid degreaser or have the floor steam cleaned.
- Use concrete patching compounds to patch chips and holes.

Cracks should be thoroughly cleaned and then filled with concrete repair caulk or patching compound.

- If the floor is too rough, consult with a floor finishing company that specializes in applying smooth surface coats.
- Consider alternative flooring materials: rubberized tile squares, wood tile squares, vinyl flooring, epoxy floor paint, solid wood tongue-and-groove strips or planks, and wood-composition tongue-and-groove

strips.

A Simple Floor Covering

Here's a rather crafty and simple floor covering: First tear large, irregular pieces of kraft paper. Lay those pieces on the bare concrete and brush on several coats of polyurethane varnish. The result is a warm-colored floor that is also sealed and easy to clean.

Walls

Insulating a garage makes it more energy efficient and helps moderate ambient temperature. Insulation also acts as a sound barrier and reduces machine noise to the inside of the house or externally to the neighbor's house.

If the garage is already finished with wallboard, you will have to make a remodeling decision. One choice would be to remove the wallboard, install insulation between the studs and replace the wallboard. Alternatives to this approach include

- Hiring an insulating company to drill holes in the wall for blowing insulation into the wall cavities.
- Attaching solid or rigid insulation board (sometimes referred to as *blueboard*) with a vapor barrier directly to the existing wallboard and then covering it with new wallboard (note: this extends the walls outward about 1½").
- Covering the existing walls with plywood or pegboard and painting them with fire-retardant paint.
- Weatherstripping both interior and exterior doors.
- Insulating the garage door. Be aware that this is not as easy as insulating walls. If the garage door is solid construction, solid insulation board might be attached to it. But don't make the door too heavy. Check with garage door companies regarding appropriate door weight and other methods of insulation.

Electrical Service and Wiring

Not having adequate electrical power in a woodshop is like having a sports car without gasoline. No matter how fine the woodworking machines or how sophisticated the lighting, unless the electrical service is specifically designed for the woodshop, you might as well whittle with a pocketknife. Not only do machines require adequate power for operation, but it is unsafe to use any

electrical tool with an inadequate power supply. Underpowered electrical tools will wear out faster, as well as being potential fire hazards.

Typically, the electrical service panel for a house is located in the garage. This makes it easy to check the panel for service voltage to the house and determine whether there are unused circuits. If circuits are available, they can be dedicated to the garage woodshop. For example, if there are three 20-amp breaker circuits not in use, one could be used for lighting, another for the table saw and the third for outlets for hand power tools. An alternative option is to install a second electrical panel that is separate from the house electrical service, often referred to as a subpanel. The subpanel consists of circuit breakers dedicated to the woodshop. Subpanels are relatively easy to install; however, call a licensed electrician if you have any reservations about your ability to handle the installation.

Insulation R-Values

All insulation types are rated with numbers called an R-value, which have been established by the U. S. Department of Energy for walls, floors and ceilings in different climate zones in the United States. Some manufacturers of insulation recommend R-values higher than the Department of Energy's recommendations. These higher R-value recommendations are usually based on the concept that more insulation is more energy efficient. Obviously, woodshops in Santa Monica, California, require less insulation than woodshops in Milwaukee, Wisconsin. Check with your local insulation suppliers to determine the correct R-values for your specific climate zone.

If you don't want machine sounds blasting through the garage door, drape sound insulation (and fireproof) curtains in front of the garage door. Or use manufactured garage doors made with insulation materials.

Almost as important as adequate electrical power is the location of the electrical outlets. There is consensus among woodworkers that outlets should be everywhere in the room, including the ceiling. My suggestion is to first design the location of cabinets, the workbench and machines, and then determine the location of outlets. There should be outlets at either end of the workbench and approximately 5' apart around the open walls. And don't forget to place several outlets at overhead locations near the workbench. Some woodworkers prefer having all outlets approximately 4' from the floor, others prefer lower outlets so

that the cords aren't suspended in the air.

Why so many outlets? It's simple: so you can avoid potentially annoying electrical tool scenarios. If there are too few outlets in the woodshop area, you will either be constantly plugging and unplugging AC cords while you work, or you will be tempted to use extension cords with multiple sockets which could potentially damage your tools because the correct voltage is not being supplied.

It's better to have outlets at the ends of a workbench so that power cords are near you and away from the work area. Electrical cords positioned over a workbench can easily smear wet glue and scatter glue bottles, screws and smaller tools as you work with a tool and drag the cord back and forth. AC cords on a workbench also can be accidentally cut or damaged by belt sanders, routers and jigsaws. Finally, an adequate number of outlets means less opportunity for cords to become tangled or to be a problem for foot travel.

Electrical wiring in unfinished basements is simplified if the joists are exposed and there is no ceiling. Finished basements will require remodeling to locate and place new wiring. The type of wiring and conduit used will vary with different building codes. Generally, wiring is routed through the joists and installed in conduit when the wires are routed down the wall surfaces. I would suggest that you select conduit that, while meeting code requirements, is also tough enough to resist being bumped by lumber and other heavy objects. I had electrical contractors install wiring and lights in my woodshop in Syracuse, New York. They drilled holes in the joists and installed Romex cables from the subpanel to both the lights and the 110V and 220V outlet locations. Rigid conduit was used from the top of the basement wall to the outlet location.

Installing Adequate Lighting

Very often lighting is set up haphazardly; that is, the local hardware store will have a sale on 4'-long fluorescent lights and so these become the woodshop lights. Attached to rafters, they are turned on via a pull string. While this does produce light, there are better approaches.

The lighting possibilities for garage woodshops are more numerous than those for basements because of the ease of access to natural light through walls, the ceiling and the garage door. If the garage window is too small, it can be removed and replaced with a larger one.

The simplest replacement types are manufactured windows which are available in many sizes and types. If the garage has open rafters, it's easy to install skylights. Skylights offer wonderful lighting with a quality unlike any artificial lighting. Natural light makes the color of finishing products easier to identify and use, both on and off wood. And during the winter months, the psychological lift of working in sunlight is extremely positive.

Adding windows to garage doors is fairly straightforward. If the garage door is articulated, with frame and panel construction, some of the panels can be

removed and replaced with either safety glass, acrylic or Plexiglas. I advise against using standard window glass because garage doors are easily bumped and the opening and closing process usually includes some sort of impact.

House contractors usually install little more than a single bulb with an on/off pull string in basements. Which, of course, is totally wrong for a woodshop. If the basement ceiling is finished, it's tempting to retrofit lights onto the ceiling surface. Although this is easy to accomplish, the effect is a lowered ceiling, which hinders your efforts to move long or tall objects. Consider recessed lights in finished ceilings; if the basement ceiling is unfinished, install 4' or 8' fluorescent lights between ceiling joists.

Garage Woodshop Security

Fear and worry are two different human conditions. Fear is a natural reaction to a terrible and immediate situation. Worry is self-manufactured nervousness. Secure your garage woodshop with common sense. There are a number of devices and procedures to keep everything safe: installing door locks and dead bolts; closing doors and windows; installing machine on/off switch locks; shutting off the circuit breakers to the woodshop; maintaining a low profile and minimizing noise (unwanted advertising); knowing your neighbors; not loaning tools; keeping fire extinguishers and first aid kits handy; and keeping a list of emergency telephone numbers near the telephone.

Garage Shop Ventilation

Fresh air is of paramount importance in a woodshop. Not only do you require clean air for breathing, but air that is too wet, dry, dusty or stale affects the quality of the woodworking project. Poor air causes finishes not to adhere or set up properly. Wet air causes wood to expand (and later shrink when moved to a drier area), as well as rust and stain tools and machines. Stale air contains assorted pollutants that affect wood, tools, finishes — and woodworkers.

The simplest ventilation system is windows and doors. However, some caution is in order. Open windows and doors lead to a degree of interaction with the outside world. Noise and dust will leave the shop and visit the neighborhood. Bugs seem to quickly find open shop doors and may bite you, leave tracks on freshly varnished surfaces or burrow into stacks of wood and lay millions of eggs. Open windows and doors also broadcast the fact that you are a woodworker. While this may be a good form of advertising, you may not want to tell the world that you have expensive tools and machines.



To heat this woodshop, a small gas furnace has been placed in the corner.

If a ventilation system is deemed a worthy investment for both woodworking and health reasons, it's prudent to consult with ventilation specialists. A system should be designed to bring a continuous flow of fresh air into the shop and to filter the exhausted air. This type of ventilation system is usually designed for specific shops — there are no off-the-shelf systems available. A basic unit will cost between \$1,000 and \$2,000.

If you decide to install a ventilation fan unit, the type found in most home improvement centers, there are a few cautions. Be certain that the fan motor is explosion-proof and dust-proof. Solvents such as lacquer thinner, alcohol, acetone and paint thinner are very flammable. When these solvents become fumes and are airborne, they are still flammable. It is very dangerous to vent fumes through a fan motor that could spark or that is not made for venting flammable solvents. Fine dust is also highly flammable and potentially explosive, so enclosed motors that are designed for use around dust should be used.

Also consider that when cold outside air is brought into the shop, the warm inside air is exhausted. If the woodshop is heated, that means higher heating bills due to the constant loss of warm air as it is vented from the shop.

In this day and age, you simply cannot vent fumes and dust into the outside environment without some repercussions. Even home woodshops must — or

should — abide by community air quality directives and laws. Furthermore, neighbors generally are not tolerant of noise, dust and clouds of fumes invading their space.

Heating the Garage Woodshop

Heating the woodshop is a difficult issue. Working in a warm room is often thought of as a luxury because heating units are potentially dangerous around woodworking solvents and materials and because a separate heating unit or system is thought of as too expensive. If you live in a warm climate, heating the woodshop might not be necessary. However, a warm, dry woodshop will stabilize humidity, thus keeping lumber at a constant moisture content; the warm air will also help prevent rust. Always check local building codes and with your local fire department regarding the installation of heating units in the woodshop.

THE BASEMENT SHOP

For many years I had basement woodshops, and I can say that although there were many good things about the location, there were also many disadvantages. However, the basement is a reasonable woodshop location, especially when cars, boats and motorcycles are parked in the garage.

There are many benefits to the basement shop. First, the basement woodshop that is accessed through the house is generally more secure and less apparent to the outside world than a garage. Noise isn't as likely to bother the neighbors. Basement woodshops are warmer during the winter months, and it is both easy and comfortable to work in a basement woodshop at any time of day. For example, on especially hot summer days, basements offer a wonderful escape from the heat. Since there are no large windows and doors, there can be generous amounts of wall storage. Unlike a garage, which is constantly used for storage and foot travel, the basement is somewhat out of the main pathways and can usually be sealed off by closing a single door.

The main problems with basement woodshops are access, stairs, overhead height, ventilation, noise and dust. Moving lumber, heavy machines and finished constructions in and out of basements can be difficult because of basement stairs, hallways, corners, doors and less-than-straightline pathways to the basement. Moving heavy objects can be further complicated by floor-to-ceiling heights, especially in stairways and around heating ducts, pipes, lights and other overhead projections.

Basement Shop Access

A typical basement might be accessed from the kitchen, often via a hallway and several doors from the garage. If you plan on using lumber, the transportation of that lumber to the basement may well cause serious family discussions! Carrying a single 10' board can easily damage doors and door frames, floor mouldings, walls, shelving, cabinets, picture frames, carpets, windows, lamps, lights and

kitchen counters (along with everything on them). It's no wonder that some woodworkers have a radial arm saw in the garage for cutting boards into shorter lengths before moving them to the basement.

Installing Doors

One option for basement access is to install an exterior bulkhead hatch or cellar door. If your basement already has a cellar door, then you are set. However, if you are considering the installation of one, several factors must be considered. The cellar door requires its own foundation, normally to the same depth as the basement. That means that a hole approximately $8' \times 8' \times 10'$ will need to be dug, which may compromise existing drainage systems. The cellar door area should not interfere with plumbing pipes and electrical cables, and it should be placed where the grade is the lowest and slopes away from the foundation of the house.

Bulkheads are easier to install if your basement is constructed of cinder block, brick or stone. I considered having a bulkhead installed in our basement. Because the basement walls were solid concrete, I consulted a cellar door specialist. He said the job would not be a problem, but as we proceeded to discuss details a few red flags appeared. It would be necessary to use diamond saws to score the concrete, and both the sawing and the subsequent sledgehammer work would produce volumes of fine dust that would travel throughout the house. We decided that the work area could be isolated with plastic sheeting, but I wasn't thrilled with the idea of concrete dust floating around my stationary machines (downstairs) or my wife's kitchen (upstairs). However, what finally killed the project was that the contractor told me to remove all hanging lamps and wallhung items from the entire house. When I asked why, he replied that the basement walls were about 12 years old and well-hardened and that the sledgehammer work would not only rattle the entire house but also pop out drywall nails throughout it. That did it. Since I wasn't willing to renail, replaster and repaint all the upstairs rooms, I decided that I could do without an outside entrance to the basement.

Reducing Irritants in the Basement Shop

It takes a very tolerant family to live with machinery noise just below their feet. The constant sound of dust collectors, the screaming sound of routers and the high-pitched whine of table saws all will travel throughout the house. Another invasive woodshop material is dust. Even when using dust collectors, dust seems to migrate to the furthest areas of the house. Fumes and odors from finishes also can permeate an entire house. Noise, dust and fumes are not the sorts of things most people want to have in their home.

Basement Shop Ventilation

Air in a basement woodshop can be damp, dry or stale. Humidity, dust, finishing fumes, mold, mildew, air circulation and ventilation all are related problems in

the basement woodshop. The typical basement is more humid during the spring and summer months when the furnace isn't used; when the furnace is used, the basement dries. This alternating cycle of humidity and dryness will affect lumber and joinery by either swelling or shrinking the wood. The only effective method of moderating this cycle is to adequately moderate the air quality. Typically, the things that can be done are to cover sump pump holes, seal basement walls with sealers and basement paints, provide good air ventilation from the outside (windows and fans) and operate dehumidifiers all year long.

Tired of Working in a Gray Basement?

Do you have a basement woodshop with bare concrete walls and are you tired of the drab bomb shelter look? First brush and clean the concrete or masonry walls. If there is efflorescence, that is, a powdery substance, it is likely that moisture is seeping through the wall. Wire brush the efflorescence. It may be further necessary to clean the walls with muriatic acid (carefully follow the product's instructions) or an etching compound, which is usually safer than muriatic acid. If water is seeping through cracks or seams, seal them with a hydraulic cement. After the walls are cleaned and sealed, apply a waterproofer, such as UGL Drylok Waterproofer. This type of waterproofer is a thick paint-like material which is brushed on. It is usually available in white, but it is also available in a limited number of other colors.

One other note, if there is basement moisture and water seepage, check the outside foundation areas for how the water is percolating into the basement. Look at the condition of rain gutters, the grade angle of the soil next to the house, and poorly functioning drainage pipes. Repair the problem.

chapter five

Maximizing Your Shop Space

IMAGINE 100 EMPTY COLLEGE dormitory rooms. Each of those rooms has the same dimensional configuration, and each has the same furniture. Now fill those rooms with college students and wait a month or two and those rooms will no longer resemble each other. The unique personalization process will make it difficult to imagine the original sameness of the rooms. Individualism, personal interests, budgets, creativity and experience are just some of the factors that shape those rooms. The same is true in the woodshop. If 100 woodworkers were given the same size room in which to create woodshops, there would be 100 variations on woodshop layout. Be comfortable and enjoy the locale. Personalize your woodshop.

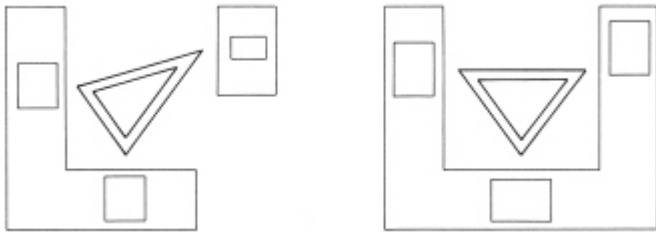
DESIGN WITH YOU IN MIND

Fundamentally, the layout of your shop should be safe, comfortable and reflect your personal style of woodworking. While it's interesting to study another woodworker's woodshop, you must always relate what you see to your own needs, tools, materials and room location. Ultimately, the ideal woodshop is the one in which you are comfortable. Personal satisfaction is one of the main reasons for woodworking. There are too many references to the perfect woodshop in books and magazines; when I see these woodshops, I always feel that they are impersonal and lack character and individuality. Truthfully, when only you know what's on cluttered shelves and in boxes of odd and ends, or what a curious jig-type object is for, you have achieved that unique woodshop that is yours. The perfect woodshop is a concept, not a real place.

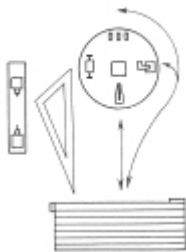
USING THE WORK TRIANGLE

A designer fad that surfaces occasionally is the work triangle. The triangle concept is based on the notion that there is a maximum efficiency pattern to a work area. It is frequently applied to kitchen layouts; that is, the work pattern between sink, refrigerator and range. The best work triangle configuration is when the sides of the triangle are equal (or nearly equal) and the total length of the sides is 14 to 22 feet. This preliminary design layout tool has some merit when it is applied to the woodshop, if for no other reason than to determine principal work areas and efficient placement of workstations and storage locations. If the work triangle becomes too large or strangely shaped, it may be necessary to reorganize the work area layout. For example, it's of little value to have hand tool storage too far from the workbench or to have tools in an awkward location. Likewise, certain tools, machines and accessories should be located so that the operator can comfortably use them in interrelated processes (for example a bench grinder and a lathe).

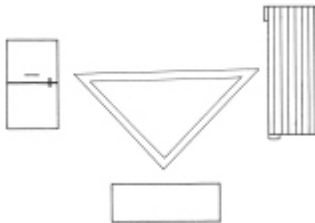
In the woodshop, it's important to create a layout that is both comfortable for the woodworker and efficient. However, the work pathway might be circular, triangular or another shape. What is important is to design a layout in which there's a relationship among various work areas, traffic patterns, windows, doors and all the other features of a room. For example, many woodworkers think the workbench is the principal focal point in the woodshop. If that is so, machines, tools and accessories that are used the most should be in a direct pathway to the workbench. In this case, in addition to a conveniently placed hand tool storage area, a drill press, miter saw and band saw, which are the significantly used machines, should be located 5' to 10' away from the workbench. The secondary machines — a jointer, table saw or joinery machine — would be slightly further from the workbench. Overlaying the primary and secondary work patterns are factors such as being able to move lumber freely or to avoid stepping on cables, air hoses and dust collector hoses.



Here are some typical work triangles showing work area layout and the triangular pattern of motion between work locations.



This work triangle includes a workbench, a lathe and round work surface mounted on a post.



This is a work triangle between a workbench, a cabinet and a table saw.

BASING LAYOUT ON SEQUENTIAL WORK FLOW

Often, the experts refer to the notion that work should be done sequentially; that is, woodworking procedures can and should be done in a methodical, step-by-step sequence:

1. Rough lumber is cut to length with a radial-arm saw.
2. Rough lumber pieces are flattened, smoothed and thickened with a planer.
3. Rough edges are smoothed and straightened with a jointer.
4. Semifinished lumber is resawn with a band saw.
5. Resawn wood is smoothed with a jointer and planer.
6. Smoothed pieces are cut to specific lengths and widths with a table saw.
7. Joinery is done to workpieces with hand tools, router and so on.
8. Workpieces are glued and clamped.
9. Glued-up assembly is sanded.
10. Finish is applied.

If this sequence is properly followed, the layout of machines, tools, accessories and work areas would be ranked (or used) in this order:

1. Radial arm saw
2. Workbench
3. Planer
4. Workbench
5. Jointer
6. Workbench
7. Band saw
8. Jointer
9. Planer
10. Workbench

11. Table saw
12. Workbench
13. Joinery tools
14. Workbench
15. Assembly and gluing
16. Sanding
17. Finishing

RELATING MACHINE FUNCTION TO LAYOUT CONSIDERATIONS

The recurring feature of this sequential-use list is that the workbench is used repeatedly and most machines are used for unique (limited) functions. The radial arm saw is used for cutting lumber to length, the planer is used for thicknessing and smoothing boards, the jointer is used for squaring edges, the band saw is used for making different thicknesses of lumber (resawing), the table saw is used for the final sizing of boards and joinery machines are used for cutting joints (i.e., dovetails or mortises and tenons). If this process is followed as a regular routine, it can be used as a template for woodshop layout.

Start With Initial Cutting

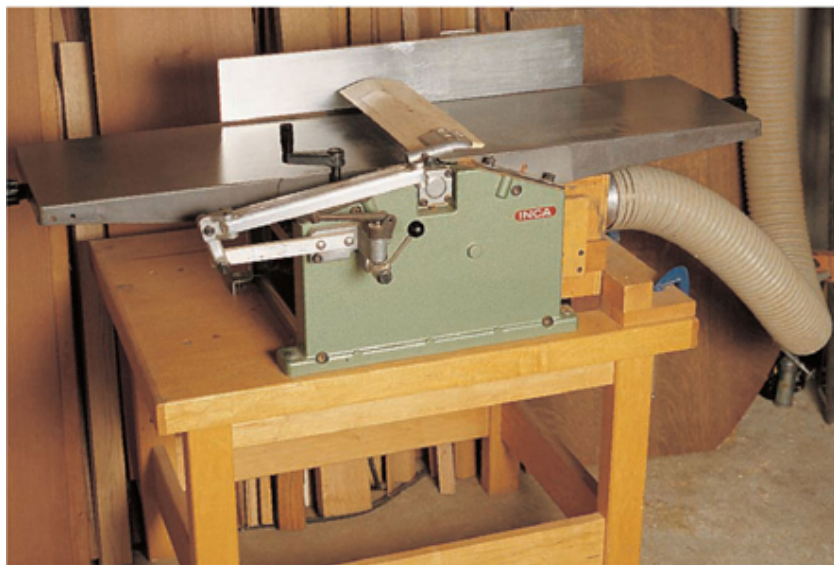
Begin with the premise that lumber and sheet materials should be near the woodshop entry door; that way it won't be necessary to move heavy and awkward materials through the woodshop. Station the initial cutting machine — probably the radial arm saw, panel saw or sawhorses and a circular saw — near the lumber and sheet material storage.

If a radial arm saw is set up on a long table placed against a wall, the area beneath the saw is often used for storage. I have seen several useful adaptations of this space: storage for roll-around cabinet modules, fixed cabinets and drawers and open-shelf storage for shorter pieces of wood. The size and shape of the woodshop affects which style of storage is used. In large rooms the radial-arm saw is usually some distance from the main work area. This generally makes fixed cabinets and drawers less appealing, because of the walking distance, and makes open-shelf storage more attractive. If the woodshop is small and compact, the use of modular cabinets maximizes storage and tool usage.

Facing Materials

Once lumber is cut to a manageable length, the planer is used. The planer requires an open workspace on either side. The open area is defined by the length of the longest lumber entering and exiting the planer. The traditional stationary planer is large and heavy and is usually oriented on the long axis of the

woodshop. The new suitcase (or lunch box) size planers are lightweight, portable and easily moved to an open area. Since the concept of a portable planer is relatively new, most traditional woodworkers haven't gotten accustomed to the idea that the planer can be stored on a shelf when it's not being used. Newer woodworkers, however, are beginning to use the planer somewhat like a router or circular saw, that is, taking it from the shelf when it's needed and then storing it away.



This is the Inca combination jointer/planer with 10¼" knife head.

The jointer is often located against an uncluttered wall because, like the planer, it requires an open area for infeed and outfeed clearance. The most common jointers have 6"-wide cutter heads and 3' to 4' bed lengths. Both planer and jointer are far more efficient if the machines have cutter heads that are the same width. Oddly, very few planers and jointers are made this way, even when they are from the same manufacturer. This is based upon the (relic) premise that jointers are used for edges and planers are used for surface widths. In reality, the best method for preparing boards (to make them flat) is to first smooth and flatten one board surface on a wide jointer. Once the surface is flat, place the flat surface against the planer's flat surface and feed the board into the planer so that the rough side is smoothed by the cutter. This produces dimensionally flat wood, free of twists, cups and distortions. If rough lumber is fed directly into a planer without having one flattened surface, the surfaces will be planed smooth, but the board will have any twists or cups originally found in the rough lumber. The only machine solution for this woodworking dilemma is to have a wide-surface jointer.



Hannes Hase has a commercial business making windows and doors, and his woodshop is in an odd-shaped and odd-sized room. He uses a Felder combination machine that includes a table saw, a jointer and a planer.



The Felder machine rotates upon a swivel base so that each function is easily accessible. Note that the planer tables are raised.

Realistically, these machines are rather heavy, large and expensive. A worthwhile alternative is the combination jointer/planer. The advantages of this type of combination machine are twofold. First, you have one machine instead of two. Second, a variety of combination machines with cutter head widths from 10"

to 24" are available, making it much easier to work with wider boards.

The basic design of the jointer/planer machine incorporates over and under the cutter head use. Jointing and flattening work is done on the top surface of the machine, as on a standard jointer; planing is accomplished by feeding the board under the table and into the lower area of the cutter head. I strongly recommend the combination jointer/planer, especially if woodshop space is limited and you want dimensionally flat and stable boards.

BAND SAWS The band saw has numerous and valuable applications, including cutting curved edges and resawing. Resawing is possibly the most useful application if only because it is nearly impossible with any other machine. Resawing lumber requires adequate space for the lumber to enter and exit the band saw. Typically, the band saw is positioned near a wall so that the cutting direction is parallel to the wall. However, if the band saw is too close to the wall, it's difficult to use the machine for cutting curves because the workpiece will most likely rotate into the wall.

One interesting solution is locating the band saw in front of a door. When resawing long lumber is necessary, the door is opened and the cuts are made.



In this placement, notice the doors behind the band saw. They can be opened when the saw is being used for resawing long boards.

Secondary Cutting and Shaping

PLACING A TABLE SAW The location of the table saw requires careful consideration. The table saw is generally used as both a primary and secondary processing machine. Primarily, it is used to cut long, wide boards to smaller lengths, or to cut full-size sheets of man-made materials to smaller sizes. Secondary work consists of the final shaping of boards, cutting joints, grooves, dadoes and moulding profiles. Each of these elements has specific design requirements. Primary processing requires adequate area around the table saw to permit the handling of large boards and sheets. This means that there should be both infeed and outfeed space for the safe handling of materials. Under no circumstances should material bump, or be deflected by, surrounding tables, cabinets or other woodshop items. The operator should have absolute control of large pieces while using the table saw. Many experienced woodworkers attach support tables on either side and on the outfeed side of the table saw to support oversized boards and sheets. Never attempt to cut a full-size sheet of plywood or particle-board on a table saw that doesn't have ancillary support tables. The sheer weight of plywood held suspended in air over the back of the table saw by the operator, plus the spinning saw blade, is an accident waiting to happen. Furthermore, using the table saw to crosscut the ends of long boards is also foolhardy.

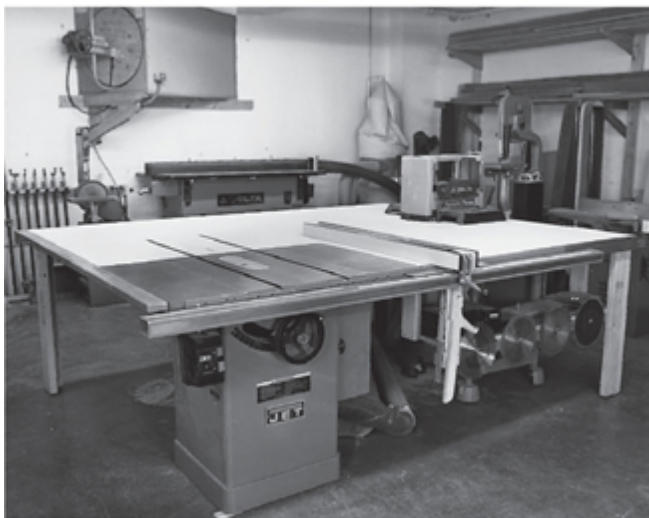


Tom Dailey's table saw features a mobile base and fold-down extension table.



The Inca saw has a shop-made router table inserted between the saw's main table and extension. The router table compartment is sealed, with a dust collection port mounted on the back side.

DO YOU NEED A SHAPER? Ten to twenty years ago it was fairly common to find shapers as part of the standard woodshop machinery. However, many new woodworkers think that the router table replaces the shaper. I don't think that the router table actually replaces the shaper, but many woodworkers rely on the router table as the principal machine for making dadoes and grooves, shaping edges, joinery and frame and panel constructions. Part of the reason for this popularity is that there are many magazine articles featuring router tables: The router is a very popular tool and there are hundreds of different router bits. The sophistication of the router is a modern success story. Plunge routers with variable speeds and 2 to 5 hp are now very common. And there are now routers specifically designed to work upside down under a router table.



Dean Bershaw's cabinetmaker's table saw features an oversize table area. This permanently installed table makes the handling and cutting of sheet materials much easier. The table is large enough to also support a planer machine.



Doug Matthews added a modest-size table to his table saw. Note how the Workmate holds an outfeed roller at the back of the table saw.

The shaper as a machine of choice has fallen out of favor due to several factors. The shaper hasn't changed all that much during this time of the router table development, and many hobby woodworkers feel that the shaper is more dangerous than a router table. This fear, distrust and rejection of shapers is, I think, based upon several perceptions: Shapers have large cutters that make large

cuts, thus appearing more aggressive (i.e, more dangerous); shaper cutters are more expensive than router bits, and shapers are more expensive than routers; common router functions are improved and made easier when done with router tables; and shapers haven't really been marketed to hobby woodworkers.



A custom stand for a jointer and a sander is in the Dailey shop. Note the dust collection system.

Actually, there are several important and real differences between the two machines. One of the main differences is that, excluding special adapters, shaper cutters are designed to cut board edges. Shapers operate in the 6,000 to 10,000 RPM range; while variable-speed routers run at 8,000 to 24,000 RPM. Also, the more professional shaper models have tilting spindles, forward and reverse switches and interchangeable $\frac{1}{2}$ ", $\frac{3}{4}$ ", 1" and $1\frac{1}{2}$ " spindles.

WILL A ROUTER TABLE DO? Router tables allow both edge work and board surface work. However, in spite of the large-diameter router bit trend, routers are limited to $\frac{1}{4}$ ", $\frac{3}{8}$ " and $\frac{1}{2}$ " shanks. Even with a router set at 8,000 RPM, I have never felt comfortable using 2" (or greater diameter) router bits. If I do use a larger router bit, I make many light passes, raising the bit ever so slightly until the final cut is made. In my opinion, router tables are very useful with piloted bits and for cutting dados, grooves, rabbets, finger joints and other light cuts requiring cutter bit diameters of $\frac{3}{4}$ " or less. The general safety rule is: Use lower RPM speeds for heavier and larger diameter cutters.

PLACING A SHAPER OR ROUTER TABLE Whether it's a shaper or a router table, there are several essential layout considerations. Both of these machines require space for moving wood in and away from the machines. And they both require rock-solid stability: Under no circumstances should these machines be unbalanced when they are used. Many shapers feature rightangle feet attachments so that they are easily bolted to the floor. I have seen few router tables bolted to the floor, and yet, they are used to cut grooves in 8' lengths of plywood. Just imagine the suspended weight of this wood as it exits the cutter and is hanging on the outfeed side of the router table. Shapers are generally constructed with the motor located in the lower areas of the body, creating a lower center of gravity that helps to stabilize the machine. In order to stabilize router tables, the framework or body should be as large as possible. If you are making a router table out of plywood, adding drawers near the floor (and filling them with tools) will enhance stability. Tim Hewitt at HTC (makers of metal mobile bases) has sold many bases for both shapers and router tables. His product stabilizes these machines because the mobile base has three wheels externally located on a welded metal frame. The location of the wheels is important because being outside of the machine and frame increases the footprint size of the machine. HTC has had no complaints or problems relating to shaper or router table stability.

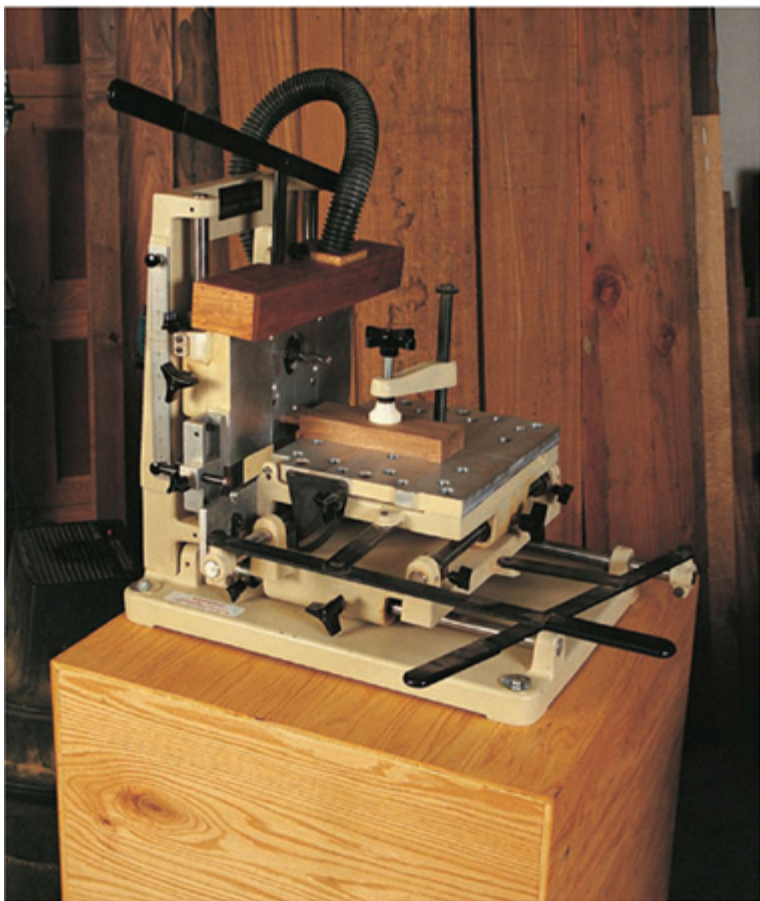
Both machines have three active sides — the infeed, the outfeed and an open side. All three require that the adjacent areas be clear of obstructions. The fourth side, the side behind the fence, is usually positioned near a wall. Shaper and router table space requirements are determined by the length of workpieces. If, for example, frame-and-panel cabinet doors are the only thing made, the clear area should be no less than 4' on the three active sides. However, if you are shaping or routing entry door pieces or floor-to-ceiling cabinet sides, the clear area for the infeed and outfeed directions should be at least 10'.

Using a Joinery Machine

The compact joinery machine is relatively new to the woodworking world, but because of its usefulness, it's being found in more and more woodshops. This machine has a router mounted horizontally and permits cutting action along X, Y and Z axes. That is, the horizontal router can be moved up and down, and the table holding the workpiece moves in and out and side to side. These machines allow for the efficient cutting of mortises and tenons, dovetails, finger joints and such.

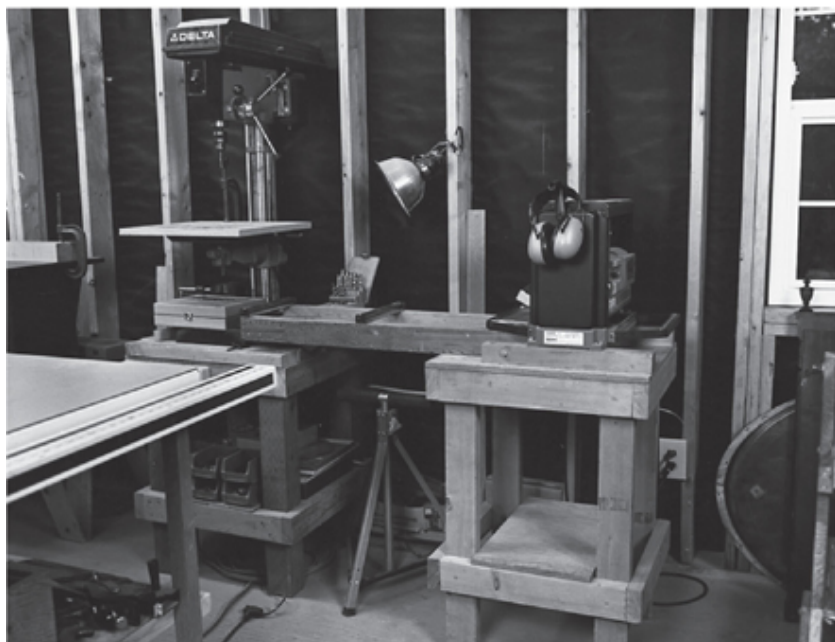
Because this machine is used for joinery, the workpieces are shorter and smaller, thus not requiring large open areas around the machine. I use a Multi-Router joinery machine mounted on a mobile base, and when I need it, I move it from a storage area to a suitable work area. In use, a joinery machine probably is easier to manage when it's near the workbench. For example, if you are making a set of six ladderback chairs, that translates into 102 pieces, 156 mortises and 156 tenons. That's quite a few pieces to keep tidy. The workbench is ideal for sorting, organizing and keeping track of all the pieces and their joinery situations. The only drawback to this machine is that the horizontally mounted router flings dust

and chips over a wide area, like a geyser of dust.



Here is the Multi-Router joinery machine with a custom-made dust hookup.

If you plan on using this machine near clean areas, I would suggest that you construct some sort of dust collection device. Factor the location of a joinery machine into your layout and provide for a 4" or 5" flexible dust collection hose to dangle directly over the router bit area. That way, the discharged debris will be caught while it's airborne. Normally, dust collector ductwork is attached to specific machines and is rarely dangled near the workbench. If you do place a dangling collection hose near the workbench, be certain to add an open/close gate or a large plug at the end of the hose: There is no reason to have an open hose anywhere in the woodshop, especially near the workbench.



Here are simple workstands for a planer and a drill press.

MOVING AROUND THE SHOP

Once the sawing, planing and joinery are finished, all that is left are the final stages of woodworking: assembly, gluing, sanding and finishing. These stages all require space — both for your movement while working and calm space while the workpiece is glued, clamped and finished.

Open Up Space With Mobile Tools

Most small woodshops are tightly organized, with walkways, and little open space. Yet, assembly and finishing require open space. Generally, the solution is to move equipment out of the way to open up space; moving equipment can be facilitated if machines are mounted on mobile bases. However, heavy machines without mobile bases probably shouldn't be moved. Dragging a machine across the woodshop will most likely injure you and damage the machine and floor. Commercially made mobile bases are available for just about any machine. HTC has a catalog offering a comprehensive supply of well-made bases for any type and brand of tool. They also will make customized bases for older or unique machines.

If you decide to make a mobile base, don't make it so that the machine is easily tipped or the wheels are too large. It's very easy to make custom stands, just make the wood frame as low to the floor as possible, use lockable caster wheels, and

design it so the wheels are off the floor and out of the way when the machine is used.

Harry Charowsky has a modest-size woodshop and all his machines, tables and workbench are on mobile bases of his own design. He uses an outdoor covered area adjacent to the woodshop to move the machines into when he's not using them. Harry installed a removable threshold to make it easier to move heavy machines through the door. The thresh-old is a wide board with an attached standard-size threshold. It simply rests on the concrete and tightly seals the room from outside air when the door is closed. When he needs to move things, he just lifts it out and then there is no bump to impede moving things in and out.

Focus on the Workbench to Save Space

Another common assembly solution is to use the workbench for the final woodworking steps. The problem with using the workbench for assembly, gluing and finishing is that workbenches aren't necessarily wide enough for some furniture and cabinet constructions. And the workpiece is usually too high for comfortable work. A workbench height of 12" to 24" is ideal for assembling furniture; however, a bench at this height is useless for many other projects. A simple solution is to have low sawhorses to temporarily support a sheet of plywood, particleboard or MDF. Assembly and clamping require a perfectly flat surface, so the sheet material should rest as flat as possible on the sawhorses. I've seen many woodshops that have the sheet material attached with screws to a simple frame, which is nothing more than four edge pieces and several crossframe pieces. When it's not in use, the flat-surfaced assembly is leaned against a wall or used as a catchall for general woodshop use. Once the sheet material is worn out (chipped, gouged, dried glue spots, etc.), simply flip it over and use the other side until it too is hopeless, and then replace it with a fresh sheet.

Plan for Glue-Up and Assembly Space

I have bruised myself more during the slow time that occurs while a workpiece is clamped than during the entire construction process. Why? I think it's because I've lowered my guard. While sawing, planing and so on, I am very focused on what I'm doing. But after the workpiece is clamped up and just sitting there, I'm usually cleaning up, putting tools away and not paying much attention to that clamp handle protruding out into the walkway. Therefore, leg and hip bruises. The moral of this tale is that clamped workpieces require an out-of-the-way place because of their disruption of normally open spaces. Or, you could simply leave the room while the glue dries.

Don't Forget About Ceiling Height

So far, woodshop layout has mainly focused on floor area. The other dimension that should be factored into layout plans is floor-to-ceiling height. While it may be impossible to increase the height within an existing woodshop, there are several things that you can do to maximize floor-to-ceiling height.

The most troublesome feature of woodshop height is the difficulty involved in moving long boards. Even if you are primarily lathe turning, carving or doing other small-scale projects, there will be times when lifting lumber is required. Lifting and transporting lumber is further complicated by the location and height of machines, workbenches, hanging objects and storage units. Furthermore, light fixtures are often lower than the ceiling. Moving an 8' board can make you feel as if you are jousting with the dark knight or battering down the castle wall!

Obviously, if you are designing a new woodshop, the simplest thing to do is to increase the floor-to-ceiling height. Ceiling heights of up to 12' will make almost any woodworking easier. When a new house is being built over a basement of concrete blocks, inquire about having one or two additional rows added to the basement walls so that there will be more overhead room. (I'm sure the additional construction expense will be negated when you use the basement woodshop, plus the additional height will probably increase the value of your house.)

Dealing With Low Ceilings

If you are setting up your woodshop in an existing garage or basement, there are several methods of dealing with standard room height.

1. Recess all light fixtures flush to the ceiling.
2. If fluorescent lights are suspended below the ceiling, install the fluorescent lights in commercially available clear safety tubes (if the light is broken, the glass shards remain in the plastic tube).
3. Remove or minimize all objects that hang from the ceiling (unnecessary light cord and so on).
4. Position machines and storage units next to a wall when moving long items. Having an open center area in the woodshop will facilitate moving long lumber.
5. Rough cut long lumber outside the woodshop.
6. If there's a window, use it for negotiating long lumber into the woodshop.
7. If the ceiling is paneled or finished, consider removing the ceiling material so that the rafters are exposed. The open area between rafters, especially above the workbench area is useful for maneuvering boards. The exposed rafters also permit additional storage and places to hang items. Dust collector ducts, air lines and wiring can be routed above rafters.
8. Work within your limits. If you do have a small and cramped woodshop, be realistic and build things that fit in the room. It is dangerous and frustrating attempting to build large items when the room size is more

suited to small, handheld-size items.

Planning for Dust Collection

No matter how the final woodworking stages are done, it is a process that effects the entire woodshop — and sometimes the nearby living quarters. The most obvious by-product of this stage is sanding dust and finishing product fumes. Additionally, the woodshop may even be more cramped while a finish is drying. These factors affect woodshop layout in the following manner: Since dust and fumes can be controlled by proper collection and ventilation, it makes sense to arrange the woodshop accordingly. Set up the dust collector and sanding and finishing areas away from doors and windows — there is no need having air currents spreading dust over a wider area. Design the layout so that dust doesn't travel more than 1' to 2' from the work area. If possible, have the dust collector hidden behind a partition or screen. Even the ceiling-mounted air filtration units can circulate fine dust, and it may be necessary to reposition it until a minimum circulation of dust is determined. By minimizing dust, there is less work when applying finishes. Cleaning the entire woodshop is a tedious chore complicated by waiting for airborne dust to settle before being able to apply a finish. In fact, oil finishes are probably popular simply because they don't need a dust-free woodshop. Varnishes and, to some degree, lacquers, don't take kindly to fine dust. If you do have a dust contamination problem associated with varnish applications, there are many finishing books with instructions on how to rub out rough varnish finishes.

chapter six

Customizing Your Woodshop

THERE ISN'T A FORMULA FOR the ideal woodshop. There is you, your requirements, your budget and your expertise. Don't get sidetracked by the unnecessary.

Sam Maloof, a great American woodworker, tells the story about being approached many years ago by several very earnest engineers. They had slide rules (definitely pre-calculator), protractors, tape measures and clipboards filled with charts. Their quest was to determine the proper heights, widths, lengths and shapes to construct the ideal chair. They wanted to interview Sam about his chairs, because Sam made the most comfortable wood chairs around. (In my opinion, they are even more comfortable than upholstered and pillowed chairs.) These bright and well-meaning engineers were looking for a formula, a template, or a system of shapes and angles for building something that would apply to everyone. Sam was amused by their questions, because he didn't have a formula or a chart for building his chairs. He told them that he built a chair by feel: He sat in it, and if he was comfortable then the chair's owner would also be comfortable. The young engineers left, scratching their heads and pondering this natural approach to chair design.

NO TWO SHOPS ARE ALIKE

This story relates to designing woodworking shops because I've never met two woodworkers that have woodshops of the same shape or size. Nor have I met two woodworkers that have the same tools, machines, lumber pile or specific woodworking style. And these differences exist even though woodworkers tend to read the same books and magazines. There are simply too many personal features, budgets, locations and room configurations for there to be significant similarities between woodshops — or for me to say there is a uniform woodshop design. I know a lathe turner who specializes in turning miniature objects, and yet her woodshop is large enough to park an airplane in it. I also know woodworkers who have full shops in single-car, low-ceiling garages and are building plywood cases and cabinets. To illustrate one very simple problem in generalizing woodshop design, suppose that two woodworkers have bought exactly the same tools and plan on setting up a woodshop in order to build exactly the same wood projects. The only difference is their woodshop configuration: One is a 12' × 30' rectangle with two doors and windows on three walls; the other is a 19' × 19' square with no windows and one door. Even though both woodshops have approximately 360 square feet, it doesn't take much to visualize that wall storage, machine placement and overhead lighting will be very different for the two woodshops. Windows and a second door create such limitations that only creatively designed storage units are effective.



Luthier Robert Girdis had used a small room for many years to make beautiful guitars.



Let's say you just purchased a house with an extra building, such as the one shown in the three photos on this page. How would you design both the ground-level and loft spaces into a woodshop?



This is the ground-level view of your imaginary new building.

What is appropriate for designing a woodshop is considering a standard set of variables that more or less apply to every woodshop. Sort of the “food, clothes and shelter” basics of the woodshop. For woodshops these elements would be: woodshop location, interest, finances, machinery, tools and storage.

Study existing woodshops. In spite of the inevitable differences with your future woodshop, existing woodshops do offer ideas and potential problem-solving solutions. Study machine locations, especially their relationship to other machines and open space (work areas). Note the locations of workbenches and storage areas for frequently used tools. Other principal concerns are lumber storage, finishing supply storage, finishing areas, clamp storage, electrical outlets, dust collection ducts and openings. Ask “Why did you do that?” and take note of the response.

START WITH PEOPLE YOU KNOW

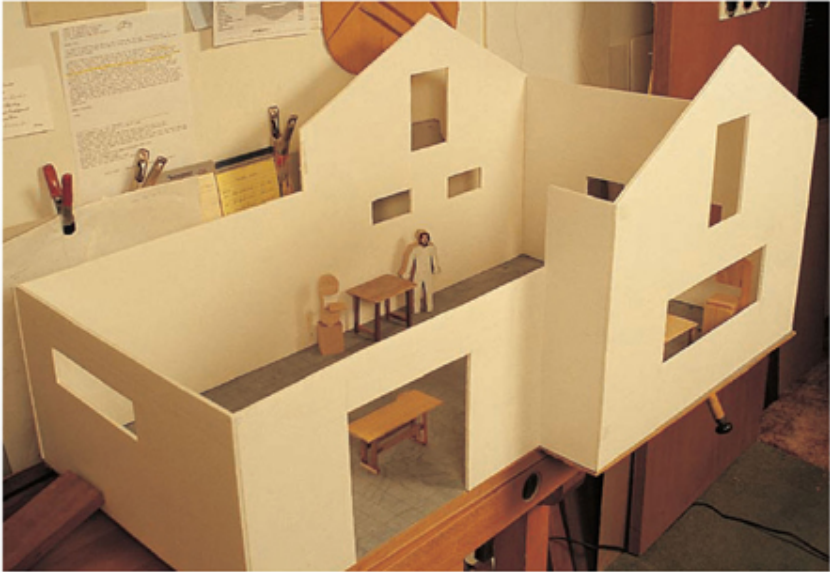
To find woodshops, first talk with friends and neighbors who do woodworking. Because they are friends and neighbors, you probably can trust their advice. Joining local woodworking clubs and guilds is also a great source of information. Generally, woodworkers join these clubs to share information. And you will find that, because most of them have gone through the struggle of designing woodshops, they aren't shy about sharing their solutions.



This is the loft of your space.

Look at Schools and Pro Shops

Schools and professional woodworking shops, although they are tempting as sources of information, aren't necessarily useful for home-woodshop applications. That's because schools and professionals don't have the same purposes, room sizes, machines and tools, budgets and interests as the home woodworker. A school might be a repository of machinery valued by teachers with specific points of view; the professional woodshop might rely on expensive processing machines with no hand tool applications whatsoever. Having said that, if the opportunity arises for you to visit these woodshops, do it, and then use the information as a benchmark of a different woodworking evolution.



Before construction ever began, Robert Girdis built a mock-up of his ideal woodshop.

Additional Shops to Check Out

Other woodshops that might offer some value, if for no other reason than studying storage solutions, air filtration and workbenches, are those used by artists, jewelers, painters and auto mechanics. These woodshops will have single-purpose applications, yet each offers unique problem-solving solutions. As you study these shops, remember that your woodshop will be generalized in nature, but how a sculptor or mechanic stores tools can be invaluable information.

MAKE YOUR MASTER PLAN

All designs evolve from somewhere. There are historical and personal factors in how we perceive environmental needs. The woodshop is not some haphazard, all-of-a-sudden wild card sent to you from Mars. Typically, home woodshop design is developed from:

- what others have done
- what magazine and book editors think is important
- movies and TV
- how schools design classroom woodshops
- how commercial businesses set up for efficiency

- having a space and randomly setting up shop

Because woodworking seems like a “practical” craft, the woodshop is often set up and arranged as if it were an antiseptic, nonpersonalized room. Consider this: How many woodshops have you ever seen that have an individualistic flare? And, I don't mean handmade benches, cabinets and such. How often are there pictures of family, a bulletin board with drawings or even a potted plant? How different is the layout or how creative is the use of space?



Here's the Girdis woodshop under construction. The woodshop is located on the house property.

I have visited many woodshops and have come to divide woodshops into two camps: the utilitarian and the artistic. The particular woodworking emphasis is not important in this observation. Carvers, turners and furniture makers are all subject to the same two divisions. What is important is the attitude and personality of the woodworker.

The utilitarian woodshop relies on a no-nonsense approach to work. Machines and cabinets are rigidly arranged, there is a formality to tool location and the woodworker has to adapt to the limitations of the room. These woodshops seem to be extensions of the machines and the work materials and less of the owner. Wellcrafted cabinets, workbenches or other man-made shop aids, while usually lending an air of the owner's skill, aren't the issue. I'm referring to the overall nature of the woodshop. Stuff is organized, and there is a sense that anyone visiting for the first time could quite easily use the woodshop. The emphasis is on production or, arguably, on conformity. That is, “Everyone else has a woodshop that looks like this, so I will do the same.”



You see here the corner and the workbench in the finished Girdis woodshop.

I feel that the “practical” and “production” part of woodworking is greatly overdone. While it is true that there is a need for organization and step-by-step construction methods, unless you are in a 40 to 60 hours per week woodworking business, you are building things for other reasons than production. Yet, woodworking is steeped in the lore of thousands of years of woodworking with the interpretation that objects were made for practical reasons. Everything we know and use has some historic connection to wood. There is little doubt regarding the usefulness (practicality) of most historic wooden objects and the tools used to make them. But we are now in a different time, with very different values than people had in 1940, 1840 or 1240! As a result of today's large population there certainly are quite a few woodworkers. However, in terms of the actual percent of careers, there are few people earning a livelihood at plane-and-saw woodworking. There is a large contingent of hobby woodworkers and more artist woodworkers than ever before. Leisure and hobby are now integral facets of woodworking.



This is the completed Rob Girdis woodshop. The main building measures 24' \times 24', and the attached secondary room measures 20' \times 20'. The side walls are 13' high, and it is 21' to the roof peak.



Dave Buck's in-the-forest woodshop measures 24' \times 32' with a 6' roof overhang for working outside — and staying dry.

Few machines and tools are really as cost effective as would be necessary in a

competitive business. Certainly, the nostalgia for a “traditional” woodshop is appealing, but it should not be the sole element for designing a woodshop. For the most part, we make things with wood because we like to make things with wood. But we still attempt to design our woodshops from two different styles. The first interpretation is that the woodshop should look somewhat like an early American or Arts-and-Crafts-era woodshop. The second design notion is that the woodshop should look like an Early American or Arts-and-Crafts-style woodshop, but it should also include the ability to turn out thousands of widgets a day!



John MacKenzie rescued an old chicken coop and brought it to his home property. After rebuilding it, he landscaped and decorated the woodshop exterior so that it became part of a pleasant backyard.



Doug Matthews built a barn-shaped woodshop to visually fit the rural setting where he lives; note his home is located near the woodshop. Doug restores and repairs antique furniture and has just set up a showroom in the woodshop's second floor area to display and sell antique furniture.

The artistic woodshop is more of an interpretation of the owner's viewpoint and lifestyle. There is use of paint, other than white, and the use of decoration. These woodshops are rare, but they are delightful. It's amazing what a few drawings, pictures or small objects can do for a room. Not all woodshop time is devoted to pushing wood through a machine, and the artistic woodshop offers objects for reflection or visitor curiosity. There is a definite sense of the woodworker in these woodshops.

My sense is that these rooms have evolved from conceptualizing the work spaces of fine art painters, sculptors or interior designers. Often, there is less reliance on having excessive tools. Instead, there are enough tools and machinery for the purpose of the owner. What I have seen and heard from this type of woodworker convinces me that they have very specific intentions for using their woodshop, while at the same time, they have the woodshop reflect their ideas and sensibilities. And they aren't distracted by the newest gizmo and accessory — unless it fits a need. In fact, some actually have an indifference to tools because they prefer to concentrate on the things they make. The emphasis is on making objects and less about having “one of everything.” Functionally there is often more open space and better lighting. Since there is less stockpiling of tools, there is less premium on storage.



This is the exterior of Steve Balter's shop.

The utilitarian, no-nonsense design is like a navy submarine. That is, there is the sense that once submerged in work, the sub/woodshop is isolated and requires total self-sufficiency. This woodshop, like the submarine, requires incredible nook-and-cranny storage for all the things that might be needed. The artistic woodshop, while having the necessary tools plus a bit of the frivolous, is more like a backpacker's pack in its simplicity: You might choose to leave some essentials behind, while making room in your pack for a favorite book.

After you have conceptualized your woodshop design, it's time to make a master plan. The master plan is a general plan of room size, potential features and tools. These are, in turn, filtered through your woodworking discipline and style. Create this plan with as much intensity and enthusiasm as possible. Plan as if designing a kitchen or master bedroom. Obviously, the master plan can be changed as you proceed with developing the woodshop. However, the master plan is the ideal starting point. It will be the first visualization of your future woodshop.



Steve Balter has a display room in the front of his workshop.

Choose Your Tooling and Storage

Make a list of all the machines, the tools and the storage areas that you ultimately will want.

FURNITURE OR CABINETRY SHOP If you want to build furniture, consider:

- workbench
- drill press
- table saw
- disc/belt sander
- band saw
- joinery machine
- router table or shaper
- dust collector
- jointer
- scroll saw

- planer
- air compressor

Also consider storage cabinets and shelves for:

- routers
- biscuit joiner
- drills
- clamps
- sanders
- hand tools
- spray equipment
- finishing supplies
- air tools
- lumber and plywood

WOODCARVING SHOP

- workbench
- dust collector
- band saw
- scroll saw
- grinder (powered sharpening device)
- drill press
- disc/belt sander

And storage cabinets and shelves for:

- rotary carving tools
- clamps
- sanders
- drills

- burrs and bits for rotary tool
- finishing supplies
- assorted hand tools (carving chisels and mallets)
- lumber and small pieces of wood

WOODTURNING SHOP

- lathe
- drill press
- workbench
- dust collector
- band saw
- grinder (or a powered sharpening device)

And storage cabinets and shelves for

- lathe tools
- lathe accessories
- drills
- hand tools
- sanders
- finishing supplies
- sanding supplies and sandpaper
- lumber, blocks, logs and small pieces of wood

MISCELLANEOUS NEEDS List all other important features that are useful for any woodshop

- electrical service panel
- electrical outlets (110V and 220V)
- plumbing (sinks, toilets and so on)
- secondary lighting (spotlights)
- windows

- doors
- containers for scrap wood

Design the Woodshop on Paper

Use ¼" grid paper and use a scale of ¼" 3/8 1'. First, draw the shape of the woodshop. Include all permanent elements of the room, such as support beams, steps, water heaters. On another sheet of paper, draw representational shapes of all machines, shelves and storage units and cut them out with scissors (or copy the images on page 31 and use those). Now, try the cutouts in different locations on the floor-plan drawing. Note the way that open space or machine positions differ from your preconceptions of an idealized layout. It may seem that particular machines, which should be easy to place, become difficult to locate because of windows or doors. Storage units may have to be modified from original designs because of machine placement or electrical outlets.

Designing With a Paper Grid and Paper Tools

Obviously, it's easier to move pieces of paper than machines and cabinets, and the benefits of this technique are far-reaching. Generally, the problem with home woodshops is too little space, not too much space. Placing items becomes a struggle toward efficiency. When arranging the paper cutouts, it might become apparent that the floor plan and machinery don't match. There may not be enough space for your needs. It may be impossible to have a comfortable blend of machines, cabinets, safe areas around machines and open work areas. The paper cutouts will aid in this discovery, which is part of the reason that you should include every possible item on the master plan list. Don't leave out machines and shop furniture that will be acquired in the future. Even if the purchase of something is several years off, include it in the master plan. All too often the owner of a cramped woodshop will spend too much time attempting to overcome the problem of space limitations. Storage becomes convoluted, machines are too close together and, instead of working on projects, time is spent either moving things around or finding, or hiding, objects. Be prepared for future acquisitions.

Planning for the Future

Here's an issue that's complicated and somewhat vexing: How do you know how to start out compared to where you will end up? Perhaps you've seen beautiful handmade furniture, bowls and carvings at a craft fair, and this has inspired you to take up woodworking. But you've had no woodworking lessons or experiences with other woodworkers. What do you do to get started? Let's assume that you read woodworking books and magazines, watch do-it-yourself videos and visit tool stores. All of these are very inspirationally produced by experts. But do these sources really help you to find a starting place? The question is, will you make furniture, turn bowls or carve? What if you set up a woodshop for carving and later find that lathe-turned bowls are your real interest?

Relax. When you create the master plan, realize that most machines are for general-purpose applications. Table saws and band saws aren't designed for single-purpose use. However, carving chisels and lathe tools are single-purpose tools. Fortunately, you can start out with a half dozen of these tools and not spend a large sum of money. And if you decide that carving isn't for you, it's easy to sell them. If you aren't certain of the type of woodworking you want to pursue, initially stay as general as possible, realizing that some tools are worth purchasing, if for no other reason than for experimentation.

BUDGETING FOR SHOP SETUP

If you are setting up a woodshop for the first time and have never purchased machinery, tools and supplies, don't get discouraged. I have talked with hundreds of beginning woodworkers and heard many very similar questions. Usually beginning woodworkers have specific budget amounts and space limitations as their first priorities. These conditions are quickly followed by questions about what type of machinery and hand tools should be purchased. After these issues, questions follow about specific brands, where to purchase machinery and tools, what books and magazines are recommended and where one can find how-to and hands-on instruction. The response to these questions is like the solution to a complicated mathematics problem: Start at the beginning, do your step-by-step work on paper, and progress through every step until the solution is found.

Translating that type of formula into designing a woodshop is straight-forward. Suppose that your budget is \$3,000 for machinery and tools, the potential woodshop area has 200 square feet, and you are planning on generalized woodworking for yourself and your family. First, what will \$3,000 purchase? Make a list of possible selections. Also factor into this list whether you are planning to purchase locally or through mail-order catalogs and whether you prefer machines made in the U.S.A. or those made in foreign countries.

Prioritize Your Purchases

Obviously both lists are over budget, and neither list includes hand tools, sharpening supplies, sandpaper and so on. The next step is to prioritize the tool list and purchase the most important items first. For general-purpose woodworking, the scroll saw and lathe may not be necessary. However, design the woodshop location as if all the listed machines and tool items were available. It's much easier to create the layout requirements in the planning stage than to retrodesign a woodshop when space is unavailable or wasn't factored into construction plans.

Potential Machines and Costs

LIST A

~~\$1,600~~ maker's table saw
~~1,500~~ stationary planer
~~6,300~~ stationary jointer

~~900~~ band saw
~~2600~~-duty lathe
~~460~~ 2" floor drill press
~~560~~ ll saw
~~0~~ one dust collector with duct
~~380~~ plunge router
~~800~~ ter table w/additional router
~~200~~ e jointer
~~24V~~ cordless drill
~~80~~ hish sander
~~22~~ × 24" belt sander
~~500~~ 095

LIST B

~~6800~~ actor's table saw
~~420~~ portable planer
~~600~~ portable jointer
~~360~~ band saw
~~850~~ chtop lathe
~~860~~ chtop drill press
~~960~~ ll saw
~~2000~~ g dust collector on rollers
~~200~~ hp standard router
~~800~~ ter table only
~~200~~ e jointer
~~18V~~ cordless drill
~~80~~ hish sander
~~370~~ × 21" belt sander
~~500~~ 085

If you plan on cutting large amounts of plywood and can't decide between a cabinetmaker's table saw (e.g., Delta's Unisaw), because you think it would be more advantageous for this procedure, and a contractor's table saw, because it better fits your space, consider the following alternative. Size plywood into smaller sections with a circular saw or jigsaw by cutting approximately 1/8" wider than the measured layout lines and cleaning the rough-cut plywood edges using a router, a straight bit and a clamped straightedge. Or construct auxiliary tables on both sides and outfeed areas of the table saw so that the plywood is manageable during cutting.

When I started woodworking, I had only a vague concept of what tools to purchase. At that time, there were no magazines devoted to woodworking and the hardware stores were primarily devoted to the trade (i.e., contractors and builders). And 20-some years ago, the main articles in the mechanic-type magazines were either "Table Saws Versus Radial-Arm Saws" or "How To Build a Plywood Dingy." It was difficult to find information or sources for antique tools, specialty tools, foreign-made tools or high-quality tools. Over the years, I have purchased a variety of table saws, routers, drills and assorted gadgets. Most of my earlier purchases have been replaced with upgraded versions, and the original tools were sold through the newspaper classified section. The point is, your skills, pocketbook and interests change with time. If you know what you want now, that's great. But don't worry if you aren't sure — you will know in time. So if you

can't afford a particular machine at the moment, purchase something that is affordable and upgrade later on. If you want to try something different, go ahead and try it. If it isn't right for you, it's easy to resell most tools; there's always eBay.

PLANNING STORAGE

The storage in most woodshops that have evolved over years of use is generally haphazard. It's common to see cabinets built in odd locations because the space was unused or was too awkward for other uses. When a woodshop is properly planned and designed, cabinets and shelves fit the room and present an orderliness that makes work easier. If possible, construct storage cabinets in modular units. A set of smaller cabinets is easier to build and easier to move within the room. For example, a 9'-long wall is available for cabinets. It's conceivable that one 9' cabinet could be installed. However, it's difficult to build something that large and then install it. It would be much better to build a set of three cabinets, each 3' long. In fact, build one as a start, and then build the others as the need for more storage arises.

Make paper cutouts of generic rectangular shapes to represent potential storage units. If the storage is wall-mounted above another unit or apparatus, color the elements different colors so that they are visually separated.

Storage Options:

- floor to ceiling
- wall-mounted above machines or benches
- under stairs
- under machines
- flush fit between wall studs
- overhead in rafters

PLANNING MACHINE LOCATION

Two general rules apply to the locations of the major machines — table saw, radial-arm saw, jointer, planer and band saw, in the shop. First, certain machines, like the jointer and radial arm saw, are only used from one side. Second, there has to be enough room around other machines, such as the table saw and planer, for wood to enter and exit the machine. When using the paper cutouts, a logical starting point is to place the one-side-only machines against walls. Optionally, certain machines can be grouped together, such as placing the jointer and planer side by side. But make sure to allow enough space for long boards to safely clear a machine without bumping into other woodshop items. For example, if a heavy board 2" × 8" × 80" is processed on a jointer, the operator not only has to maintain the board on the machine, but he also has to be able to take the board from the outfeed table and not ram it against other woodshop items. In other

words, the entry and exit areas around certain machines must be clear: This space is as important as the space the machine occupies.



Tom Dailey's woodshop is located in a ground-level basement. Plywood is brought in through the back door, then cut with a panel saw.

Table Saw

If full sheets of plywood are routinely cut, place the saw centrally in the woodshop and build secondary support tables. Keep the pathway to and from the table saw unobstructed so that the plywood can be safely handled and moved. For small woodshops, panel saws are an alternative to the table saw. These are wallmounted units that support the plywood, with a track-mounted circular saw for making the cuts.

Radial-Arm Saw

If long boards are routinely cut with a radial saw, the saw should be placed against a wall, with long secondary support tables on either side. Many woodworkers with basement woodshops set up a radial-arm saw in the garage and perform rough cuts there, and then move the shorter pieces to the woodshop. Note: If the radial-arm saw is in the garage and away from the main woodshop, it should be equipped with a lock for the on/off switch. This prevents children or other curious types from turning on the saw when the owner isn't present.

Band Saw

If the band saw is used primarily for ripping and resawing long boards, it too can be located against a wall. The work is moved parallel to the wall, providing a clear pathway for board entry and exit from the blade. However, if the band saw is used to make curved cuts, the board is moved in a radial manner, much like a clock hand, with the blade at the center point. For this type of use, the band saw should be more centered in the woodshop, away from walls.

Dust Collector

The dust collector, although very useful, has to be one of the most difficult machines to place in the woodshop. It has an awkward shape, and certain models radiate fine dust and noise. Ductwork, gates and connectors are also potential complications. If you don't want multiple ducts or hoses, there are portable collectors with short lengths of hose, that can be placed near a machine. This method only works if you're doing limited work with the floor free of obstructions. The best method is placing the dust collector somewhere away from the work area and using ducts to the machines.

To control the dust that settles around a collector, and to reduce the noise level, the dust collector can be located in a closet-type of room. If you choose to do this, be certain that there is air flow into the room. Cut a square hole in the door and cover it with a furnace filter. The filter keeps dust from exiting the room, and the hole will reduce air pressure within the room. I've seen a dust collector room that, when the collector was running, created so much air pressure that the door couldn't be opened. That isn't wise.

Miscellaneous Tools and Machines

A number of machines are used to primarily process shorter lengths of wood. This allows for some freedom in floor plan use. The drill press, router table, shaper, scroll saw and joinery machines can be located in less open areas. Occasionally, the router table or shaper is used for longer pieces; the machines can then be moved for these specific operations.

PLAN FOR ELECTRICAL AND PLUMBING NEEDS

When a new building is under construction, there is a sequence to the order of events. That is, electricians and plumbers complete their work before drywallers and painters. While this sequence should apply when converting a basement or garage into a woodshop, the electrical wiring and plumbing are often undervalued. It is not uncommon to see that the one or two existing outlets in the garage or basement are overused with extension cords and extension bars. If there is a laundry sink or toilet already in the garage or basement, it is usually left as is. Wouldn't it seem to be much smarter to upgrade both the electrical systems and plumbing while designing the woodshop?

Wiring the Shop

The importance of having a proper electrical service cannot be overstated. First, I advise against using very long extension cords. Not only do they create more floor clutter, but long extension cords can lead to unnecessary electrical motor wear. A representative from an air compressor company once told me that the majority of compressors returned for motor repairs were those that were used with extension cords. Apparently, owners forgot that longer air hoses were a better way to work at a distance from the compressor. I have one retractable ceiling-mounted extension cord in my woodshop. It's 30' long 14/3 SJT wire and rated at 13A, 125V, 1,625 watts. I only use it with hand drills, finish sanders and similar tools. I would never use it for band saws and other stationary machines.

The placement of machines relative to the proper outlet is fundamental. If you want to use the table saw at a particular location, then having an isolated 110V or 220V outlet at that location is mandatory. Since this section is about guidelines for designing the woodshop, the key factors are: wiring from an existing service panel (interior or exterior to the wall), installing a subpanel, outlet locations and location of lights.

Interior wiring is difficult when the wall studs and ceiling rafters are already covered. The standard technique is to cut holes in the wall or ceiling and "fish" the new wires in place using a fish tape tool. New wiring that is not within walls should be run through metal conduits that are firmly attached to the walls. If the room framework is still exposed, it's straightforward to run wiring through the studs, around windows and door frames to the service. Subpanels are a very good choice when upgrading the woodshop. They are easily mounted near the main service panel, and conduit can then be routed anywhere in the woodshop.

The design of the outlets should accommodate both the placement of machines and the use of electrical tools at various locations. There should be outlets near both ends and at the center of the workbench, as well as outlets near the open areas in the woodshop that can be used for assembly and detail work. For example, you have constructed a 3'-wide by 7'-high bookcase and want to use a router for detail work on its sides. If the bookcase is set on the workbench, it may be too high for safe and easy work. If the bookcase is on the floor in an assembly area, the work height is correct. An overhead outlet or outlet about three feet from the floor will facilitate the router's use.

Shop Plumbing Concerns

The same generalities apply to plumbing. Is plumbing necessary in a woodshop? From a design viewpoint, if form and function are considered, the question is, "What value does plumbing serve?" What I value in a woodshop sink, besides washing my hands, is that it permits me to maintain waterstones for sharpening, mix dyes and water-soluble finishes, clean the HVLP spray gun and nozzle, clean restoration projects and use the new polyurethane glues. All of which are necessities. Warning: If there is a sink in the woodshop, don't use it to dispose of toxic solvents, flammable liquids and other hazardous wastes. Water, soap, dirt and grime are the only things that should go down the drain.

Garage and basement woodshops are often near laundry rooms. This proximity permits the addition of new water pipes to the woodshop area. Copper and PVC pipes are fairly easy to work with and it shouldn't be too complicated to route pipes several feet to the woodshop. If you aren't sure about cutting into water pipes, call a plumbing contractor for assistance. Undoubtedly, he can do the work faster than a woodworker!

Once the electrical system and plumbing needs have been determined, add these elements to the master plan and draw them onto the planning grid. Hopefully, the proposed design will accommodate all of these elements.

A SUMMARY OF THE woodshop DESIGN PROCESS

1. Create a master plan of all the key woodshop elements: machines, tools, workbench, open areas, lumber racks, storage, electrical and plumbing.
2. Be realistic, as much as possible, and know your own personal interests.
3. Be somewhat hypothetical in choosing the woodshop elements. At this point you haven't spent any money.
4. Make paper mock-ups of different woodshop layouts.
5. Be reasonable. Understand that a woodshop takes time and money to create and that you can proceed at your own pace of acquisition.
6. Always consider alternatives. Buy inexpensive, resell and buy more expensive. Consider multipurpose machines. Consider hand tools instead of power tools.

Hiring a Contractor

Some tasks may be too complicated or require specific expertise. There are many advantages to hiring a contractor or other specialist when remodeling or building a new woodshop. The problem is how do you know who to hire?

Never underestimate the complexities of building or remodeling a woodshop. Just as with a house, the fundamentals of framing, electrical, plumbing, concrete, trenching and all the other construction techniques are required.

While there are many who are skilled enough or have enough time to do their own work, often it is better and

faster to have someone else do the work.

If you've done your design work and choose to hire a contractor, you must be comfortable with your choice. After all, this person is going to turn your drawings into your ideal woodshop.

Selecting a contractor isn't that simple. The building process is complex and expensive so you must be certain that it will go according to your stated objectives and budgetary limits.

- If you don't know of a reliable contractor, ask friends and colleagues for their recommendations.
- Watch for any remodeling work being done in your own area. Pay attention to any signage on trucks or yard signs. Ask the homeowner if they are satisfied with the work being done.
- Inquire at local lumber yards, building supply centers and hardware stores for recommendations.
- Check with local builders or trade associations.
- Ask all potential contractors for references and photographs of their work. Note: It's easy to have photos of any attractive project. Check photos for images of the contractor, the company's sign, some sort of indication the work was actually done by the person showing the photos.
- Once you have selected a contractor, talk with him concerning recommendations for subcontractors.
- Indirect recommendations often occur after several unrelated sources recommend the same person.

- A personal note: I don't like contractors' advertisements with only a telephone number listed. I want to see a street address or at least a city name.

chapter seven

Examining Real Woodshops

IT'S IMPOSSIBLE TO FIND REPRESENTATIVE woodshops that reveal all the mysteries of setting up a woodshop. Each of the shops that I have visited is unique and represents the owner's personality and woodworking style. The quest for the perfect woodshop really begins and ends with each person's own effort. And while it's enjoyable to peek into another woodshop, often the only transferable items are bits and pieces of problem-solving. We seem to have a collective desire to construct "model cities," "dream houses" and "ideal workshops," but the reality is that these places are curiosities. Anyone remember the futuristic cities of the 1939 New York World's Fair, Disneyland's House of the Future or General Electric's 1960s All-Electric House? The point is, while we idealize a perfect woodshop, your perfect woodshop is right in front of you — it's in the garage, the basement, the extra room, the attic or a closet. All you need to do is get started.

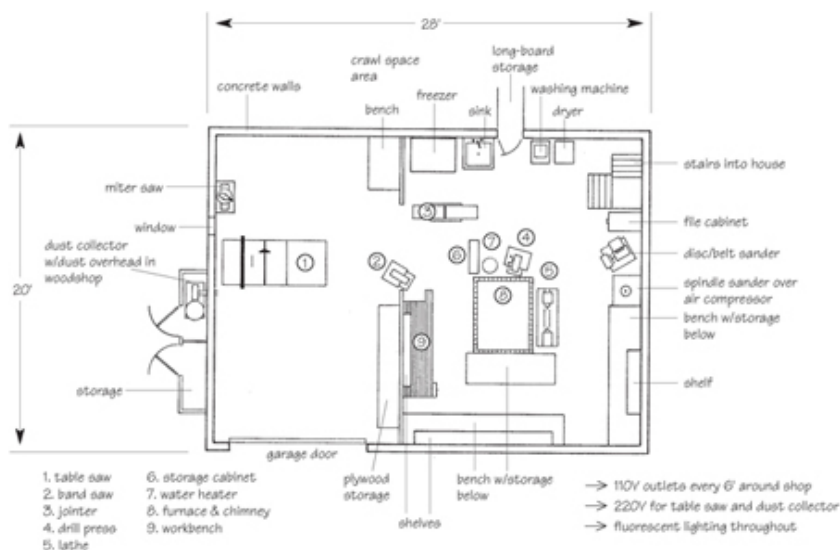
The following perspective is from Alan Boardman, a highly regarded, very talented woodworker and authentic expert on tools, joinery and wood. I attended his lectures on joinery and tuning up hand tools about 20 years ago and he showed me the fantastic adventure of woodworking. I now prize the small (marble-size) wooden puzzles he makes.

"Regarding the ideal woodshop, if one exists, I'll bet it is owned by someone who does no woodworking whatsoever," says Boardman. "My shop is a total disgrace and I love it. Every minute I spend wondering how to make it closer to ideal is a minute I am not enjoying working in it. My wife calls it my hellhole. It is a jumble of offcuts and boxes that I have long ago stopped wondering what's in them. I can hardly move about in the place or swing a board or find a precious piece of rare wood I have been saving for decades for that worthy project, yet I am always happy there and never think of food or aging pains. If others think like I do, maybe the ideal shop is better described in human terms than where every machine should be placed and how to store odd nuts and bolts. Incidentally, I haven't always felt this way. I used to dream of a perfect shop. But now that I am retired and theoretically have the time to redo it, I find that I don't want to. I like it the way it is."

The woodshops shown in this chapter can be classified into three types: the garage and basement woodshop, the separate-building woodshop on the home property and the rental-space woodshop. These example woodshops have been in existence for some time, and each of them definitely reflects the personality and style of the owner.

1 GARAGE AND BASEMENT WOODSHOP #1

MARK KULSETH'S WOODSHOP



MARK KULSETH HAS BEEN USING his woodshop for about five years. His woodshop is in a single-car garage and the adjacent laundry and storage areas in a 64-year-old house.

His woodshop measures 20' × 28' (560 square feet). It is wired from the main house electrical service for both 110V and 220V use. Additionally, some areas of the woodshop have a floor-to-ceiling height of 6' 5". Mark is a part-time professional whose main woodworking interests are making custom furniture and some repairs and restorations. He also collects antique tools.



Mark Kulseth has an older home with a single-car garage attached to the laundry room and storage area. The table saw is located near the back wall of garage.

While there is little free space in Mark's woodshop, he has maximized the existing floor and wall areas so well that he can build standard-size cabinets and furniture.

His principal machinery (in order of importance) includes:

- 10" Delta Unisaw with 52" fence and outfeed table
- 14" Delta band saw with riser block
- 20" Jet drill press
- Delta 6" × 48" belt sander
- 12"-disc sanding machine
- Jet 1200 CFM dust collector
- Walker-Turner lathe
- traditionally designed workbench

If Mark had more floor space he would add a wide-belt sanding machine, a downdraft sanding table and a 5' square work surface that is accessible from all

four sides.



Kulseth's woodshop with countertop area and shelf storage. Mark plans to install cabinet doors in the near future. Note that the spindle sander sits on the box that houses the air compressor.

There are several nifty features to Mark's woodshop: He has grouped benches and tools around the furnace and chimney, has displayed plumb bobs from under the stairs, has a hidden storage area for lumber and has combined built-in bench tops/cabinet storage and shelves for antique tools. When I first visited his woodshop I was taken with how Mark has stored tools and stuff in every conceivable location — between rafters, behind walls and suspended in corners. My thought was that if he ever moved to another woodshop, he would need significant cabinet storage to handle all of the tucked-away items hidden in his woodshop. He should also use a metal detector to be certain that nothing is left behind!



Kulseth's woodshop and more countertop and shelving for antique tools.

Safety is important in Mark's work. He says that he has learned from the mistakes of others and he always wears eye and hearing protection. There is a first aid box and three fire extinguishers in the woodshop. Also, flammable and combustible materials are kept in a metal locker. Rags are rinsed in water, air-dried and then placed in a small metal garbage can inside the woodshop.

I believe that woodworkers who work in confined areas, as Mark does, often develop a keen sense of what situations are best for ideal working conditions. Mark said that if he could design his ideal woodshop, he would have "a woodshop with ample space, wood floors, tall ceilings and maybe a separate finishing room and office, free of dust. But more than anything, I would love a shop built in a natural setting, away from the city, with mountain views, trees, a river and so on. To do this, I must have the business demands for my products."

Mark sees a relationship between himself, his woodshop and his woodworking skills: "I try to make my shop reflect my personality and skills as a craftsman. If I'm making a tool rack, I make it with care and pride to show my skills. It makes it much more enjoyable to view my tools. I also collect antique tools and many are displayed in my work area. I often reflect on the craftsmen of old while trying to solve my building problems. This reflection seems to inspire a higher quality in my craft."



Mark Kulseth uses the underside of his staircase to display his plumb bob collection.



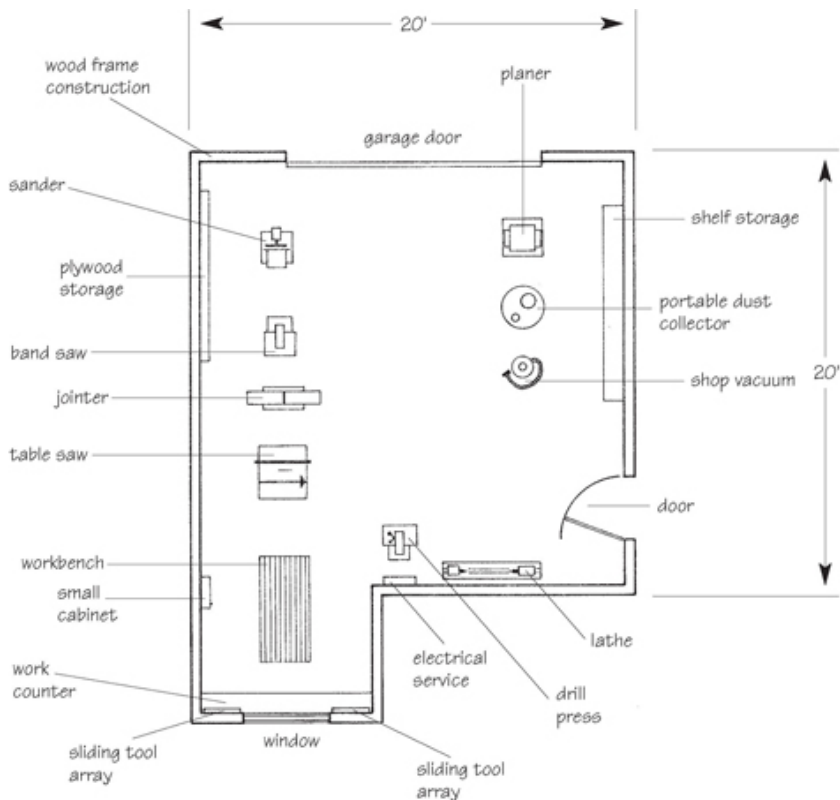
Mark Kulseth stores his antique plane collection above his workbench. An angled hold-down device is in the foreground.



A crawl space (hidden behind the chart in the photograph) is actually a large area for storing lumber.

2. GARAGE AND BASEMENT WOODSHOP #2

DAVID BEYER'S WOODSHOP



DAVID BEYL'S WOODSHOP WAS A two-car garage. The house is 27 years old and David has had the woodshop for 13 years. It measures 20' \times 20', with an 8' ceiling. It has a subpanel with both 110V and 220V wiring. David is a part-time professional who specializes in building furniture, repairing antiques and teaching woodworking. He spends about 20 hours a week in the woodshop. His principal machinery (in order of importance) includes:

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David Beyl has a two-car garage woodshop. To maximize space, there are numerous sliding panels mounted in front of the windows.

- 10" Delta cabinetmaker's saw
- 6" Jet jointer
- 14" Delta band saw
- 12" disc, 6" \times 48" belt sander
- 16" Delta radial drill press
- 12" Shopsmith planer
- Shopsmith dust collector
- 14" Delta scroll saw
- Campbell-Hausfeld air compressor
- 12" Delta lathe

David's woodshop is 20' \times 20' feet, that is, a square floor pattern with almost no nooks or crannies. Interestingly, David's concept of woodworking seems to match the straightforward woodshop layout.

He's somewhat of a minimalist and only has tools and machines that he uses. Nothing more, nothing less. The simplicity of the woodshop also lends itself to teaching woodworking. Students aren't working in clutter, and they are learning to use the basic machinery in a clean and straightforward woodshop environment.



David Beyl's workbench, shown here, features many small drawers.

Just because David has identified his woodworking style and woodshop arrangement doesn't mean that he wouldn't improve his woodshop. If he remodeled the woodshop he would include a built-in dust collection system, recessed lighting (fluorescent and incandescent), a sink with hot water, a gas heating system, a separate office area, convenient storage and a modern-design workbench.



David Beyl has small cabinets which have page-like sections for holding small tools.

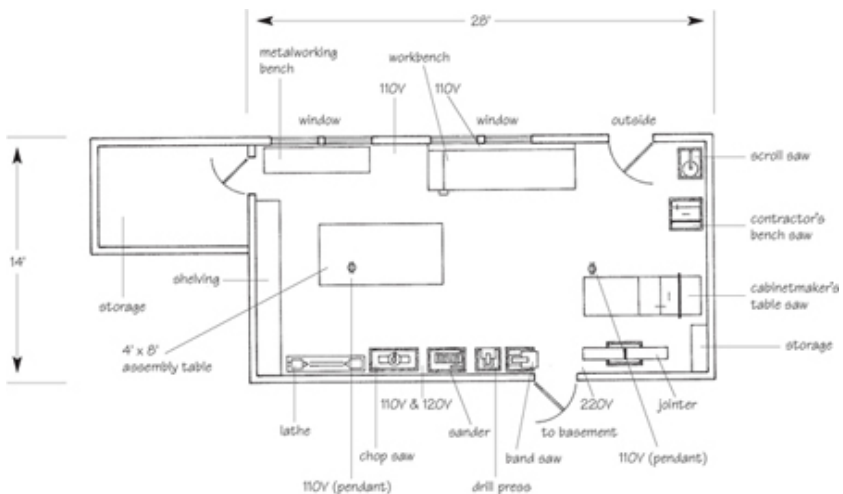
A feature I particularly admired was David's use of sliding tool storage partitions. These partitions are four panels that slide like sliding closet doors, except the units are wall-mounted and slide back and forth in front of a window. Slender tools such as chisels, screwdrivers, pliers and files are stored on the racks.



The David Beyl woodshop has a wood storage unit that is hinged at one end and then rolls out at the other end. This storage unit is used primarily for plywood and cut-off pieces of plywood.

3 GARAGE AND BASEMENT WOODSHOP #3

GEORGE LEVIN'S WOODSHOP



Note: All stationary machines (except lathe) are on casters.

THE GEORGE LEVIN WOODSHOP is located at basement level with a window view and door access to the outside. The woodshop is approximately 14' × 29', it has standard-height ceiling and is equipped with 110V and 220V electrical wiring. The house is 71 years old, and George has been using the woodshop for 22 years. He considers himself to be a part-time professional and builds Federal and Deco style furniture and other built-ins. He spends about 20 hours a week in the woodshop.



George Levin's woodshop is about the size of a one-car garage. He has a beautifully designed workbench mounted against a wall.



George Levin's table saw is mounted on a shop-made mobile base.



A heavy belt sander is mounted on a shop-made mobile base. Note the customized sander fence.

His principal machinery (in order of importance) includes

- 10" Delta Unisaw

- 10" Inca Model 510 jointer/planer
- 8" Grizzly jointer
- 14" Powermatic band saw
- 10" disc, 6" Delta belt sander
- 24" Delta scroll saw
- 6" × 32" Delta (Homecraft) lathe



George Levin's workbench and window view.

If there was space in the woodshop, George would have a panel saw. Also, if he could design an ideal woodshop, he would include a spray booth, large doors, plenty of windows, level access to the outside, wood flooring, sink, toilet, dust collection system, room for wood and sheet goods storage.

George's woodshop is an elongated rectangle, and he has optimized working conditions within the space by making mobile bases for the machines. These bases are made of wood, have locking wheels, and they are both sturdy and easy to use. It is easy to roll the table saw into a more open position, use it and then return it. Another principal feature is a 4' × 8' assembly table. This table is about 24" high, and the top is a sheet of $\frac{3}{4}$ " melamine particleboard. The table is used for stacking rough-cut pieces, for assembly and gluing of workpieces and for finishing work. When the top surface is no longer workable, it is flipped over to access the other side. And when both sides are worn out, a new piece is installed and the old top is disposed of.

George has a spectacular workbench. Its wonderfully unique construction is a fine example of craftsmanship and represents an impressive comprehension of design. The workbench measures about 3' × 12' and it is mounted against a wall.

Looking at the front, the right-side half is composed of two rows of drawers that have customized pockets for hand tools; the left side is an open area, usually filled with large sleeping dogs. There is only one metal vise, mounted on the left-front edge and it has an adjustable companion holder (workpiece support) that can be located on any of the four vertical bench supports. Instead of the typical bench dogs, the bench top has a metal track perpendicular to the vise. An adjustable stop slides in the track so that various width boards can be easily secured. Other details include a narrow tool tray located along the entire back edge, and the top surface material is hardboard. When the hardboard wears out, it is unscrewed, removed and then replaced with new hardboard.



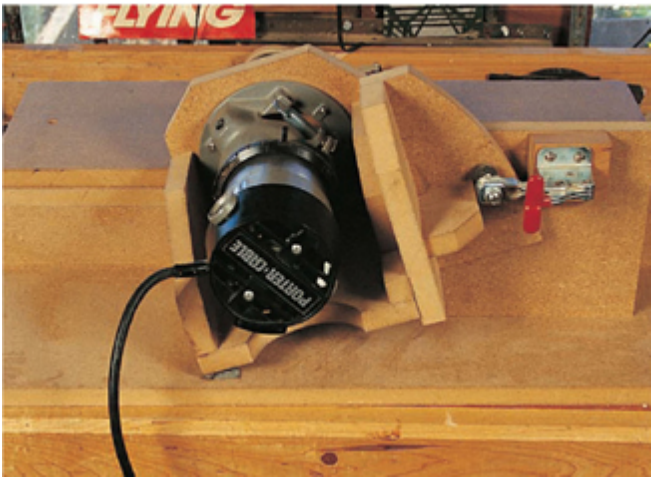
George Levin designed his workbench holding system which features a slot perpendicular to the vise. The slot contains a movable and lockable bench dog.

George has a sense of humor and his woodshop reflects his personal view of things. In a way, his woodshop is a collage of bits and pieces of personal history, world events, successes of children and just fun stuff. A plain storage cabinet is totally covered with tiny pictures of dogs, and although the cabinet contains nuts and bolts, it's referred to as the "dog cabinet." George once was an avid aviator, and so it stands to reason that the ceiling is covered with pictures of airplanes and an upsidedown remote control airplane! Where most of us have machines with the manufacturer's name prominently displayed, George has covered his band saw with vacation pictures, quotes and other less commercial concepts. There are numerous calendars from the 1960s, posters of longago lectures, old clocks and

assorted keepsakes — enough interesting things to keep a smile on anyone's face. Judging by the woodshop, George Levin is a happy man. His comments about his woodshop: “This room is an extension of myself, so it contains pictures and memorabilia reflecting some of my other interests so that I really feel ‘at home’ when I am working there.”

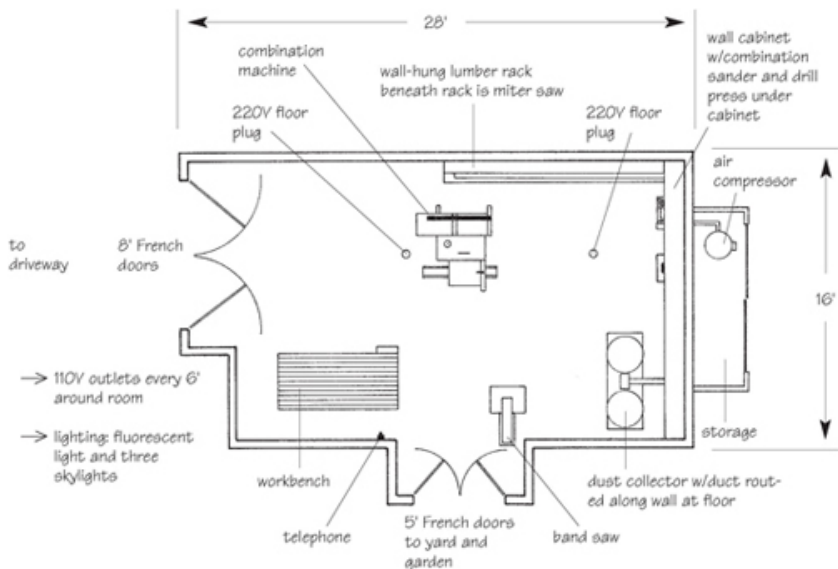


The Levin bench has drawers with custom locations for all tools.



Because the Levin woodshop is small, George has many jigs and fixtures that he uses at his workbench. Shown is his mortising jig.

1 SEPARATE BUILDING OR SEPARATE-ROOM WOODSHOPS #1
THE CHARLES CASWELL WOODSHOP



AFTER YEARS OF WORKING IN other people's woodshops, Charles decided to build his ideal woodshop.

His goal was to design a woodshop that would be on his own property and separate from the house. His house property's shape is that of a typical city lot, that is, a long and narrow rectangle. The house is an older style with the garage as a separate structure set back from the house and next to the property line. Charles removed the old garage and then designed the woodshop to look like a new garage. The exterior is reminiscent of the bungalow style, with door overhangs and clapboard siding. The major exterior feature that reveals something of the nature of the building is that Charles installed French doors instead of a garage door. Charles also built the walls with sound insulation so that the neighbors wouldn't be hearing machinery noise. From my own experiences visiting the woodshop, I had to be fairly close to it to hear the muffled sounds of a dust collector and planer being used. His soundproofing consisted of standard wall insulation between wall studs and then covering that with $\frac{1}{2}$ " sound board. Drywall board was installed in the normal fashion and the wall was finished and painted.



Here's the exterior of Caswell's shop. Note that double French doors are located where a garage door would be located.



Charles Caswell built a two-car-garage-size woodshop at the end of his driveway on a typical city lot. This interior view shows the open ceiling, skylights, lighting, main storage cabinets and machinery. Not seen, to the right side, is a traditional workbench. This woodshop is noteworthy for its straightforward layout and comfortable and uncluttered work conditions.

Charles is a full-time professional woodworker and spends over 50 hours a week in the woodshop building furniture. His woodshop is 2 years old and has 450 square feet, 110V and 220V wiring. There are electrical outlets at convenient wall locations and 220V floor plugs near the table saw. His principal machinery (in order of importance) includes:

- 10" Robland X31 table saw with sliding table

- Robland X31 jointer/planer combination machine
- 18" Laguna band saw
- Ryobi miter saw
- AMC radial-head drill press
- Robland X31 shaper
- Robland X31 horizontal mortiser
- Grizzly belt/disc combination sander



You can see here how clamps are stored in Caswell's woodshop.

Charles had a four-bag dust collector in the woodshop but he felt that the hookup at the machines was inadequate; that is, the factory-constructed fittings were ineffective at the source of dust. He also wanted a larger, more power unit, including a chip separator located in a separate space. After the first photographs of his woodshop were taken, he replaced the upper filter bags with filter bags that trap dust to the 5-micron level. This considerably reduced dust blow-back into the work area, but he still wasn't satisfied. Subsequently, he sold the four bag dust collector and all the 4" ductwork and installed a cyclone collector with 5" ductwork and a Delta ceiling hung air filtration unit. The cyclone was an immediate improvement; it is much quieter and there is now minimal dust in the shop.

Charles also has a 6-hp, 80-gallon air compressor located in a shed behind the back wall. He doesn't consider it to be a principal tool because he uses it mostly

for cleanup work. He bought the large compressor partly because of value and partly because it's quieter than the smaller "oil-less" compressors. Under normal usage it cycles on a few times a week.

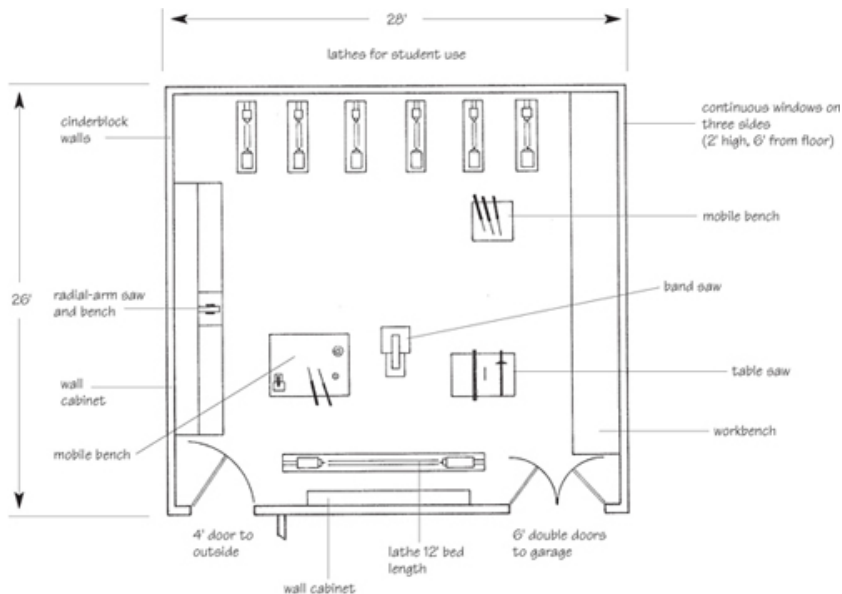
The woodshop features a very comfortable bright and airy working area with an open ceiling, skylights and one 5'-wide and one 8'-wide French door. For storage, Charles built a single row of cabinets across the back wall. These cabinets are located at approximately head height and are the main storage in the woodshop. There is also a wall section with pegboard, used for oversize tools and accessories. There is lumber storage, positioned above the miter saw area, which is used for planed boards and material being prepared for the next work project.

When he first set up his woodshop, Charles made a beautiful, traditionally designed workbench. At the time, the workbench seemed like a good idea. Now that he is busy making furniture, the workbench is not used and is taking up floor space — space that he needs for other purposes. Currently, the workbench is supporting a vacuum press, and he is debating on what to do with the workbench — to sell it or put it in storage.

The woodshop reflects Charles's attitude about woodworking: It is thoughtful, organized and well crafted. He has enough tools and machinery for any work, and the room is clean and open so there's no inefficiency due to clutter and congestion. He is very content with his woodshop and would only add a warehouse area for curing and storing lumber.

2. SEPARATE BUILDING OR SEPARATE-ROOM WOODSHOPS #2

RED BARTHOLOMEWS WOODSHOP



THE TED BARTHOLOMEW WOOD-shop is one of the most unusual woodshops that I've visited. Ted's woodshop measures 26' × 28' (728 square feet) with a 9' ceiling. There is both 110V and 220V wiring. The room, built as a woodshop 20 years ago, is located next to a garage. The most noticeable feature of the room is that there are windows located 6' from the floor, continuous on three walls. These windows are 2' high, and the lighting is similar to that of skylighting. What makes the woodshop unique is that Ted is a "serious amateur" who specializes in woodturning: He manufactured his own wood lathe and likes turning large bowls. He also teaches woodturning.



Ted Bartholomew's woodshop is attached to a two-car garage. Windows are continuous on three sides of the shop.



Ted Bartholomew's custom lathe is designed for working on either side of the machine. The portable tool storage cart is easily moved throughout the woodshop.

There are large and small movable tables and carts for storing lathe tools and accessories. His lathe features a pneumatic forward and reversing system so turning work can be done on either side of the lathe. In order to make it easy to access lathe tools, the tools are simply laid on a cart and the cart is moved to the area of work. These movable tables and carts also make it easier to work when there are several students working at the lathes. Ted is very happy with his woodshop but he would like to install a dust collecting system.

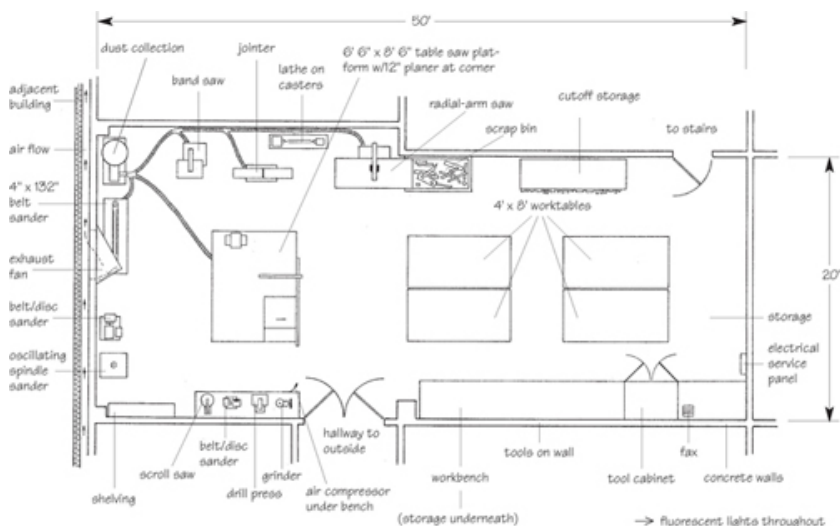
His principal machinery (in order of importance) includes:

- several Bartholomew lathes (the number varies)
- antique lathe — 4 hp, capacity of 22" overbed, 7' outboard, 12' overall
- various lathes for student work
- Walker-Turner 16" band saw
- Craftsman 10" radial-arm saw
- 10" Delta Unisaw
- drill press

- 1" belt sander

1 RENTAL SPACE WOODSHOPS #1

DEAN BERSHAW'S WOODSHOP



DEAN BERSHAW IS A FULL-TIME professional woodworker specializing in contemporary furniture. He has been in his current woodshop 3½ years and spends 30 to 50 hours a week there. He rents part of the basement in a commercial building that was built in the 1950s. His woodshop measures 50' × 20' (1000 square feet) with a ceiling height of 7' 8" under ceiling beams and 9' between beams. There is both 110V and 220V wiring. His principal machinery (in order of importance):

- 10" Jet 3-hp table saw
- 6" Grizzly jointer
- 12" Delta planer
- 10" Delta radial-arm saw
- 9" Grizzly disc sander
- Mark 1 drill press
- Grizzly 2-hp dust collector
- router table with Porter-Cable router, Incra jig fence
- 24" Windmaster fan

- Campbell-Hausfeld 6-hp, 30-gallon air compressor
- 4" × 132" Delta belt sander
- 12" Delta lathe
- Star oscillating spindle sander
- Delta sharpening center



Dean Bershaw's woodshop is located in the basement of a commercial building. This area is used for smaller work projects and tool storage.



Dean Bershaw has four workstations with surfaces of 4' × 8' sheets of particleboard.

Having a commercial operation in a concrete basement offers several challenges worth noting. Basements in industrial/commercial areas aren't necessarily the easiest locations to find. Both vendors and customers require clear instructions in order to find Dean's woodshop. Although Dean doesn't expect walk-in business, he does invite designers and buyers to visit him while projects are under construction. Other basement complications include no direct access to the outside, risk of water damage (broken/leaking pipes) and ventilation.

Dean's woodshop is in the back section of the building's basement; consequently there are no windows, doors or other vents to the outside. However, at one time there was an opening in a wall which was later bricked in when another building was built next to that wall. Dean removed the bricks and discovered that there is a 5"-wide space between the buildings. He built an angled exhaust fan housing and installed it in front of the opening. This clever arrangement exhausts stale woodshop air into the 5" space. This fan, although it does remove residual dust particles, is not meant to be a dust collector — it is used to refresh and circulate air in the woodshop. And there are no windows on either of the walls at higher locations (i.e., no one will be bothered by exhausted woodshop air).

Although water leakage is always a worry, it has yet to happen. Preparing for such a problem, Dean has made all storage units, tables and workstations as modular units so that they are easy to move.



Air circulation and ventilation are critical in Dean Bershaw's basement woodshop. The only direct access to the outside is an opening to a 5" space between building walls. He built a diagonally mounted fan housing so that air could be exhausted into the narrow space between buildings.

If Dean remodeled his woodshop, he would add a spray booth, office space and living quarters. He would include space for multiuse capabilities, such as automotive work and metalwork, and he would also add windows, higher ceilings and open-ings at opposite ends of the woodshop for through-circulation.

The principal factor that makes this location attractive is the rental rate. The rent is affordable, allowing him to keep his operating costs low. He is willing to compromise with ceiling height and no windows in order to be competitive. Dean realizes that time is of the essence when doing custom work. Any woodshop improvements have to serve a purpose and must not require significant amounts of time to accomplish. Dean also states: "I have bought tools for a specific job but they all have subsequent value for general-usage applications. In my view, the less specific the application, the better."

1. ANOTHER APPROACH

JAMES LEARY'S WORKPLACE

JAMES LEARY, A SUCCESSFUL PRO-fessional woodworker, does mostly house remodeling and refurbishing — without a woodshop building. Instead, he takes his woodshop with him to the job site. His large van holds all that he needs; he simply drives up and begins to work. He says that he made a design choice: He could have built custom storage within the van but decided not to. Instead, he decided to use tool cases that are specific for each power tool. His reasoning was that fixed storage is somewhat limiting. For example, if a job requires drills and reciprocating saws, but not routers and power washers, he can leave the

unnecessary equipment at home. Also, the tool cases all have shapes and sizes that are easily identified for quick selection while working. And modern tool cases are easy to carry, are reasonably dustproof and water resistant and hold extra bits, blades and accessories. There is one other bonus: Customers enjoy and appreciate his readiness and thoroughness.



James Leary doesn't have the typical woodshop — his woodshop is his van. He does remodeling and general woodworking and drives his woodshop to the worksite.



Here is almost everything out of James' van.

APPLY TO YOUR OWN WOODSHOP

I have visited dozens of woodshops and they all have the basic assortment of tools, storage and such. Does having a particular brand of tools make the woodshop better? No. Does having a large space make woodworking better? Perhaps. Does personal problem-solving help make an ideal woodshop? Yes.

Although a woodcarver or someone working on small-scale projects doesn't necessarily require large areas for work, the general-purpose woodworker does benefit from having adequate space. Unfortunately, if you have 100 square feet of

woodshop, you can't simply wish up another 50 square feet to make the room better. What you can do is:

- Wisely plan out the space.
- Buy appropriately sized machines.
- Have only the machines and tools that you need.
- Build storage units to fit space.
- Be happy and build things.

From Those That Have Built Woodshops

“If I had only known ...” is often the start of conversations with those that have built their own woodshops. While there is universal satisfaction with the completed shops, everyone has tales of how complex or expensive the project was. I have listened to stories about wearing out too many tools, underestimating the volume of building materials and the hardships of doing heavy work without assistance. Some wished that they had planned for larger woodshops and others wished they had been less elaborate. And just like those that have woodshops in home garages or basements, these woodworkers also have wish lists — after the woodshop has been completed. “I need more space, I want to add a room for wood storage, I wish I had a sink and toilet, I should have added skylights, I didn't have enough money to”

Even if you have more space than necessary (which hardly ever occurs), the same basic steps apply. Each of the woodshops I have featured is a consequence of these basic steps. All of the woodworkers have adapted to the room configuration, organized the machinery and storage around their needs, and then proceeded to make furniture, turn bowls, repair antiques, collect old tools, remodel houses and lose themselves in the enjoyment, wonder and mystery of woodworking.

chapter eight

Powering and Lighting the Shop Effectively

THERE'S NO DENYING THE FACT that electricity is the fundamental necessity of the modern woodshop.

WARNINGS ABOUT ELECTRICITY

Before you begin to do anything with electrical wiring there are a few cautions. Never attempt any electrical work if you have doubts about the wiring layout or the consequences of your effort. The two agencies you should be aware of are your local building departments (usually city and county) and the utility company. The building department has electrical inspectors who can explain local codes and requirements concerning permits for the work and any necessary inspections. Requirements, regulations and amended versions of the National Electrical Code (NEC) vary from area to area. It is very important to follow the codes and guidelines established for your area. The utility agencies can assist in the location of underground cables and will recommend the correct approach to any electrical service upgrades. Often, it's less time-consuming, more economical and safer to hire a licensed electrical contractor to install new wiring, electrical service panels or other custom work. Electrical work is similar to woodworking: Both require specialized tools and supplies. If you don't have the correct tools, be prepared to rent, buy or borrow them. A visit to an electrical supply store is enough to make you realize that there are scores of supplies, many of which have to meet your local electrical codes.

VALUATE YOUR ELECTRICAL NEEDS

There are several starting points in the evaluation of electrical requirements for a woodshop. The first, and most obvious, is that if the existing room has a single overhead light with a pull chain and only one or two outlets, the room is underpowered for woodworking machinery. Check the electrical service panel for the circuit breaker to the potential shop location; if there is only one 15- or 20-amp circuit, the service will need up-grading. If you start up a table saw and the lights dim, perhaps you should stop woodworking and upgrade the electrical service.

How you upgrade or install adequate electrical service for a woodshop location is dependent on whether you're remodeling or building a new room. It's certainly more straightforward installing wiring and outlets in a new construction. Routing cables through open framework is much simpler than when walls, doors and ceilings are in place.

Electricity Essentials

There are many comprehensive books on basic wiring that detail all of the various electrical requirements and upgrades for a house. Many of these books are written for do-it-yourselfers, so they're easy to read and follow. What I want to address are the specific electrical essentials of the woodshop. These essentials are:

- safety
- adequate electrical supply
- 110V and 220V service
- sufficient outlets
- proper lighting

SAFETY RULES

There are two main safety considerations: the type required when actually upgrading a system and the safety of having the correct amperes, cables, outlets, etc., once the upgrading is done. While these may seem similar, they're distinctly different.

Proper upgrading generally consists of knowledge, information, common sense, proper tools and supplies. To safely complete an electrical upgrade requires knowing the machinery and tool electrical requirements, code-compliant installation of outlets, use of the proper types and sizes of cables, outlets, etc. If you have any reservations about any of these points, it might be best to call in an electrical contractor. After all, electrical current is invisible until there is electrical shock or electrical fire.

Never work on a live circuit. Always disconnect the circuit at the service panel. That means switching the circuit breaker to an 'off' position or removing a screw-in fuse. Remember that the electrical power will still be live to the service panel from the power utility lines (either below or above ground). So even if you switch the main power off, the power will still be live to the service. It's sort of like closing a dam's spillway: Water may not be leaving the dam, but there is water on the other side of the dam.

Be certain that the circuit is off by first turning on a light that's plugged into that circuit. If it goes out when the circuit is switched off, then you may proceed with the next step.

It's always a good idea to tell others that you are disconnecting a circuit. This is especially important when working at some distance from the service panel. You might even tape a note to the service panel warning others that you are working on the service.

Never work on any electrical fixtures, the service panel, the wiring or anything else electrical when there are wet spots, moist conditions or standing water. Dry the area as much as possible. Open windows and doors to aid in drying damp

basements. If there is moisture on the floor, construct a platform of dry boards over the wet areas.

USE THE CORRECT TOOLS

Common tools that you probably have in the woodshop that are useful for electrical work:

- mat knife — for cutting wallboard and, with the blade barely exposed, cutting sheathed cable
- hammer — the obvious
- screwdrivers — also obvious
- Allen wrenches — fittings and terminals often are secured with hex screw heads
- square-drive screwdrivers — many electricians now use screws with square holes instead of slot or Phillips heads. Squaredrive screws are fast and easy to use.
- tape measure — the obvious
- keyhole saw — for sawing holes in walls and hard-to-reach locations prior to installing boxes or cables
- hacksaw — for sawing conduit to length
- cordless drill with drill bits — the perfect drill when the power is off

Specialized Tools

- engineer's or lineman's pliers — used to twist bare wires together and then cut the last 1/8" off so that the twisted wires fit into a wirenut; large serrated jaws can bend flat metal
- diagonal cutting pliers — for cutting wire; fits in confined locations
- needle-nosed or snipe-nosed pliers — for picking up and holding small parts in confined locations
- wire strippers — adjustable to different wire gauges for removing insulation
- multipurpose electrician's wire strippers/tool — several features: wire stripper, wire cutter, crimper and bolt cutter
- insulated screwdrivers — entire screwdriver, except blade tip, is coated with insulation

- conduit bender — long-handled device for bending metal conduit to various angles
- fish tape — thin metal line for pulling cable through enclosed areas; i.e., walls and ceilings
- cable ripper — a cutting device for slitting the sheathing on cable
- electronic metal and voltage detector — a device similar to stud finder that locates any metal object and detects AC voltage within a wall
- continuity Tester — used to determine whether an electrical path is complete. Simple to use when checking fuses, switches and plugs. It has a battery and indicator light and is only used when the power is off! Handy to have, even if not an electrician.
- voltage Tester — used to determine if power is present. The probes are touched to a hot line and the ground thus causing the indicator to light. It is used with the power on. Useful for checking DC/AC voltage, outlets, motors, appliances and fuses. Useful if you have some experience working with electricity.
- volt-ohmmeter, or multimeter — used for testing a variety of conditions, including voltage, low-voltage current, resistance to ohms and continuity. Useful for checking outlets, fuses, wires, plugs, motors and electronic circuits. Useful if you have some experience working with electricity.
- circuit analyzers — look like an oversize electrical plug. The simplest version can determine if there is power to a receptacle, whether it is properly grounded and whether the wiring is correct. There are more sophisticated circuit analyzers that can check from the receptacle back to the service panel for voltage drops or for current leaks. Handy to have, even if not an electrician.







Handy electrical test equipment includes (from top left, going clockwise) a continuity tester, a voltage tester, a multimeter and a circuit analyzer.

tip

It's a good idea to have insulated handles on pliers and other metal tools. Don't rely on insulated tools as the only safety precaution, always turn circuits off before working on them.

ELECTRICAL SUPPLIES

Be certain that the electrical supplies you select are approved or meet local building codes. If you aren't sure about this, then it would be best to consult certified experts. There are too many choices — guessing which part or wire size to use is the wrong approach.

Wire is a single strand of conductive metal enclosed with insulation. Cord is stranded wires protected by insulation. It can consist of two or three stranded wires within the insulation and is used for appliances, lamps, etc. Cable has two or more color-coded insulated wires that are protected by sheathing.

In the United States, the colors of the individual wire are agreed upon: Black or red is the power or hot wire, white or gray is the neutral, and green or green with a yellow stripe is the ground wire. Sometimes ground is a single uninsulated copper wire.

Wire Type and Size

It's very important to use the correct wire size and type when upgrading an electrical system. Local codes will specify what sorts of cable and cable conduits are permitted in your area.

Wire Types

TYPE NM has a thermoplastic insulation and is capable of withstanding a wide range

of temperatures. It's used for most household circuits.

<i>Number of Wires in a Conduit*</i>				
WIRE SIZE	½" CONDUIT	¾" CONDUIT	1" CONDUIT	1¼" CONDUIT
14	4	6	9	9
12	3	5	8	9
10	1	4	7	9
8	1	3	4	7
6	1	1	3	4
*Actual number is also governed by local codes				

TYPE UF (underground feed cable) is waterproof and is used for damp and outdoor locations.

TYPE USE (underground service entrance) is used for underground or overhead service entrance and direct burial to garages and woodshops.

TYPE THW is used for outdoor hanging or indoor conduit as service entrance cables and for conduit to a subpanel.

Nonmetallic (NM) cable is the most common plastic-sheathed cable. It's often referred to as Romex, which is a trade name. The sheath is usually moisture resistant and flame retardant. Normally, there are insulated power wires and a bare ground wire inside of the sheath.

Armored cable, referred to by the trade name BX cable, has an outer armored layer, usually flexible galvanized steel, that often contains two or three wires wrapped in paper.

Conduit is usually galvanized steel or plastic pipe. It's generally available in ½", ¾", 1" and 1¼" diameters. The correct size to use depends on the diameter and number of wires inside the conduit.

Wire Size

Wire size, basically the diameter of the wire excluding insulation, is extremely important when upgrading an electrical system. There are standard reference numbers, usually printed on the outside of wire insulation, that are based upon the American Wire Gauge (AWG) system. Gauge numbers are inverse to their size; that is, the smaller the number, the larger the wire diameter. The maximum current that a wire can safely manage is stated in amperes (amps). Wire diameter and the amount of amperes are directly related. Smaller diameter wires have greater resistance to electrical current flow; consequently, as the current flow increases so do friction and heat. To avoid melting wires and electrical fires, use larger-diameter wires for heavier electrical needs.

Common Copper Household Wire (By Gauge) & Its Ampere Rating:

AMPERE RATING

~~75~~ amperes
~~100~~ amperes
~~150~~ amperes
~~200~~ amperes
~~300~~ amperes
~~400~~ amperes
~~500~~ amperes

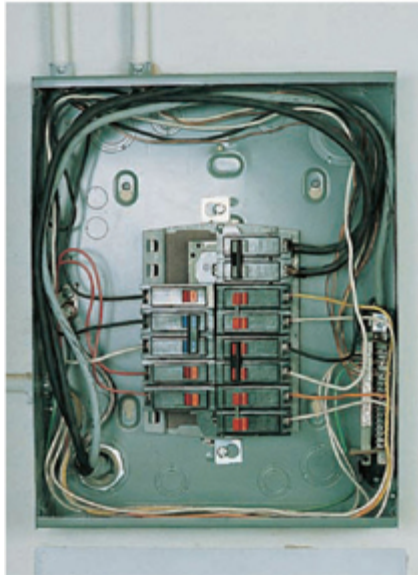
CALCULATING ELECTRICAL USAGE IN THE WOODSHOP

No matter what electrical circuits or subpanels are added to the house's electrical service, the total house load must not exceed the service rating. Generally, older homes having no electrical modernization have 100-amp services. Newer homes generally have 200-amp services. If you are not certain about the service, look at the main circuit breaker in the service panel — it should be labeled. If you have 100-amp service, consult with both the utility company and a licensed electrician about upgrading to a 200-amp service.

The woodshop is probably going to have machines and power tools, unless, of course, you're taken with the joy of only working with hand tools. Generally, woodshops will have one woodworker using no more than two machines at one time (table saw and dust collector, drill press and vacuum). The advantage of this is that the electrical system isn't going to need to support the simultaneous operation of all the woodshop's machinery. As you plan the electrical layout, make a best guess as to the frequency of use of tools and machines. Not only will this aid in determining circuit requirements, but it will also aid in planning the placement of outlets. The reality of upgrading woodshop electrical systems is that it's often easier to install separate outlets on separate circuits than to have one circuit with multiple outlets. For example, in my woodshop I have three machines requiring 220V service: the table saw, jointer/planer and band saw. Rarely, if ever, are two machines running at the same time. So it's possible for the three machines to have their outlets wired to the same circuit. However, these machines are located in different areas of the woodshop and it was much easier to install outlets at each of the machine locations and route wires through one or more conduits. Since there was adequate space in the subpanel, it was a straightforward addition of circuit breakers and wire. The exception to this is the dust collector, which is also 220V. Because it's operated simultaneously with each of the stationary machines, there was no choice — it required its own circuit.



Above is a typical subpanel installed above the main circuit breaker panel. Below the main panel is a Gen/Tran unit — used for connecting a portable generator to the main panel in the event of a power outage. At left, you see the subpanel cover removed for a better look at the breaker switches and wiring.



Typical Machine & Tool Ampere Ratings

Note: Machines and tools are 110V-120V with exceptions noted.

AMPERAGE TOOL

80' Cable saw
 10' Contractor's table saw
 94" Band saw (½ hp)
 10/35 Gallon 220V
 13" Miter saw
 6'5 Jointer
 13" Planer
 Drill press
 6'4" x 48" Sander
 26' x 36" Shop 220V
 12' Lathe (¾ hp)
 Scroll saw
 16' x 11' x 2' Bag
 17' x 23' Motor (4 bag)
 20-gallon Shop vacuum
 3½-hp air compressor
 Router, 1 hp
 Router, 3 hp
 16' Sander, 4" x 24"
 16' Jointer
 Finish sander
 Spindle sander
 3/8" Hand drill
 Bench grinder
 Strip sander, 1" x 30"
 4'8" saw

Circular saw
Heat gun
Benchtop mortiser
HMBP spray gun turbine

The National Electrical Code sets minimum capacities for circuits regarding use and amperage

- Small appliances — 20 amperes
- General lighting — 15 or 20 amperes
- Stationary tools — multiply the machine's amperage by 125%. The 125% factors the electrical surge that occurs when a machine is first switched on. For example, a 12" planer rated at 15 amps ($1.25 \times 15 = 18.75$) will require a 20-amp circuit.

OUTLETS, SWITCHES AND PLUGS

Until the day comes that we can use tools powered by wireless telemetry, woodshops will need outlets and switches. When designing a new electrical layout, placement of outlets and switches requires planning, guesswork and a bit of luck. The reality of woodshops is that work projects, new machines, relocation of cabinets, stacks of lumber and other fluctuating events will block existing outlets and switches from access. Often, well-thought-out locations aren't that handy once the woodshop is used. The ideal situation is never having to use extension cords because you have outlets wherever you work. This can be accomplished simply by locating outlets three to five feet apart throughout the woodshop, including the ceiling. This may seem excessive, but it's not. There are too many work conditions that occur away from the workbench area: Using a vacuum, sander, plate joiner, rotary carving tool or heat gun are but a few of the applications possible.

Two scenarios for installing outlets: If the woodshop area is a new construction, wires should be installed within the wall framework. If wall coverings are already in place, outlets can be installed on the outside of the wall surface if metal conduit and metal outlet boxes are used. Always check your local electrical codes concerning this type of installation. External conduit adds flexibility to designing and locating outlets, simply because conduit can be routed just about anywhere. Metal conduit pipe is easily bent to a variety of shapes and angles with a conduit bender. One option for the 90° bend at corners is to use short prebent right-angle conduit pieces. These are attached to the straight conduit with sleeve connectors. Conduit pipe can be cut wherever necessary and outlets installed.

Steven Gray has an unusual (for the home woodshop, that is) electrical system. His woodshop features overhead electrical rails. These feed rails are connected to the main power panel. What is unique is that trolleys slide within the rails, and lights or AC switches can be attached to the trolleys. The feed rail is both 110V and 220V. Both voltages are usable depending upon how the contact trolley wheels are aligned within the feed rail. It's a very neat system, with movable

electrical items all in one track, both 110V and 220V outlets and different types of lighting.

Acceptable Outlets

- Grounded three-prong, 120V, 15 amp
- Grounded three-prong, 120V, 20 amp
- Ground fault circuit interrupter, 120V, 15 amp and 20 amp
- Grounded three-prong 220/240V

Note: Ungrounded two-prong 120V receptacles are unacceptable for shop use.

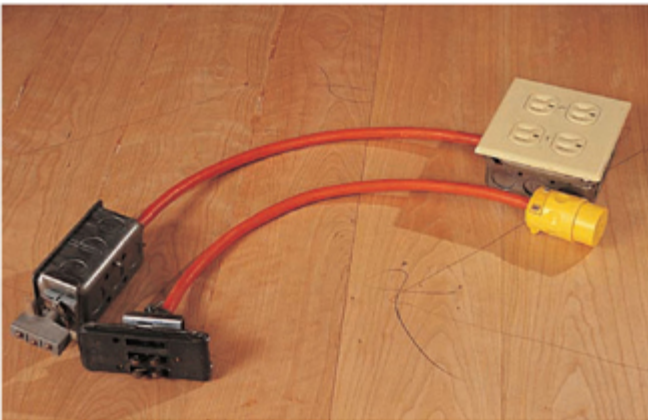
Use grounded three-prong 20-amp outlets in the woodshop. This will accommodate most woodworking tools (see the tool amperage chart on page 77). If an existing woodshop has ungrounded two-prong outlets, turn off the main power and replace the old outlets with grounded outlets. If there isn't a ground wire to the outlet, attach one from the outlet to the receptacle box or the nearest cold water pipe. Check that the ground is functional by using a ground tester.



Overhead electrical feed rail system in Steven Gray's woodshop.



Close-up view of the electrical feed rail. Each rail is on its own separate 30-amp circuit. The rail accepts any combination of outlets and lights. Both 110V and 220V can be used simultaneously.



Switches and plugs are installed on the electrical feed rail system.



Various lights are installed on the electrical feed rail system.

Ground fault circuit interrupter outlets (GFI) are designed to protect you from shock. GFI outlets monitor current; if the incoming and outgoing currents aren't within 0.005 amps, the GFI instantly cuts off the electricity (in $\frac{1}{40}$ second). GFI outlets are found in newer houses, generally in bathrooms and outdoor locations where someone may have wet hands and feet. If you are installing outlets in damp basements or around sinks, you should install GFI units. As with all electrical installations, check local codes or hire a licensed electrician if you have any questions regarding the installation.

Switches

Switches are rated according to amperage and voltage, so it's important to choose the correct switch for compatibility with circuits, wire and outlets.

There are four basic types of switches:

- Single-pole switches have two terminals, one for the incoming hot wire and one for the outgoing hot wire. The switch toggle is imprinted with ON/OFF.
- Double-pole switches have four terminals and are used primarily for 240V circuits. The switch toggle is imprinted with ON/OFF.
- Three-way switches have three terminals. One terminal is labeled COM (common), and the hot wire is connected to this terminal; the other two terminals are switch leads. Two three-way switches are used to control a circuit from two different locations. The toggle has no ON/OFF imprint.
- Four-way switches have four terminals and are used with two three-way switches to control a circuit from more than two locations. The toggle has no ON/OFF imprint.

Plugs

Despite the proliferation of battery-powered tools, there are still many tools and machines that have AC plugs. Usually these plugs receive quite a lot of use and wear, often because of the neglectful act of pulling the cord and bending the prongs. When plugs need replacing, replace them with dead-front plugs. This type of plug has no exposed wires or screws and the prongs are surrounded by smooth plastic. If there are screws on the plate surrounding the prongs, they are recessed and are only for securing the plug body together.

If you are attaching wires to a 125V plug with three prongs, connect the black wire to the brass terminal, the white wire to the silver terminal and the green wire to the green or green terminal.

Polarized plugs are identified by having one brass prong (hot) and one silver prong with a wider tip. The plug is designed to fit into an outlet in only one direction. This plug is commonly installed on smaller appliances and woodworking tools.

LIGHTING THE WOODSHOP

There are two distinct types of lighting in most woodshops: fluorescent lighting and minimal use of all other types of lighting. Fluorescent lighting fixtures are probably used the most because they are inexpensive and commonly available. Other lighting types are thought to be useful as house lighting and not for woodshop lighting. While there is some truth to the generalization that fluorescent lights are useful in the woodshop, perhaps their limitations are overlooked.

Woodshop lighting is woefully neglected in today's woodworking. There's a cornucopia of aftermarket improvements to almost everything electric within the woodshop except lighting. Lighting stores and hardware stores usually have jumbled lighting displays, making it nearly impossible to view and judge lighting fixtures one at a time. The one exception I've found is a GE display of different fluorescent lamps. This display is a set of identical photographs, individually set in a series of recessed boxes, each lit by a different fluorescent lamp. This display nicely reveals the colorrendering differences of fluorescent lamps.

Unfortunately, few light fixtures seem to be designed specifically for woodshops. Those that are tend to be either sterile-looking white metal devices or cheap-looking clip-on reflector hoods. This simply means that it's up to the woodworker to solve shop lighting questions through both personal experience and research. Trial and error may seem like a difficult path to follow, but it does allow you to customize your woodshop.

When evaluating lights and fixtures, consider that there are several key elements to using light: color, shadow, contrast and reflection. These are the products of lighting that we see in both dynamic and subtle ways. They give usefulness, meaning and emotional connection to woodworking. Many artists

refer to the process of their work as “painting with light.” Woodworkers should also control and use light for both acceptable room lighting as well as artistic and aesthetic reasons.

Color is perhaps the most subjective and difficult aspect of light. A simple request proves this point: Define “red.” We may generally agree upon the notion that tomatoes and apples are red, but it's extremely difficult to describe a particular color and have agreement on it: Color perception is in the eye of the beholder. Furthermore, location, situation and light source will change color. For example, if a person is holding an apple and standing in the glow of a sunset, the apple will look different (warmer) than when it's sitting on a workbench situated under fluorescent lights (cooler). If the apple is placed under a green light, it will change color again — it will appear grayish. Imagine the effect that lighting will have if a dark cherry workpiece is subjected to warm or cool lights. Will that “golden oak” stain look yellowish or greenish?

Elements That Offer Some Control Over Color

The problem isn't just that color perception is subjective, it's often that a woodworker and client can't see the same color. Suppose that you restore a Stickley chair using only fluorescent lights and the client places the chair so that it's lit by an incandescent lamp. Color for a Stickley piece is very important. In fact, collectors pay such close attention to the color that it and value are connected. The chair will appear different under those various lights — and the client probably won't be happy. This difference of color is a function of wavelength variations. Different lighting will have warmer or cooler colors with many different combinations of spectral differences.

Warmer light is often thought of as the daylight at sunset or the light from an incandescent bulb. Cooler light is the light of noon, an overcast sky or fluorescent light.

One commonly used term that describes the differences in light is temperature, expressed in degrees Kelvin (K). This scale is invaluable for selecting light to match your needs. Generally, lower degrees Kelvin represents a warmer appearance and higher degrees Kelvin represents a cooler look.

Note: The Kelvin reference, while useful, is somewhat of a “ballpark” number. The visual color of an object will be influenced by such things as the age and darkening of a bulb or by the fact that two different lights (natural and warm) may have the same Kelvin value but different color renderings.

If your work demands color-balanced conditions so that the workpiece color is true, the woodshop lighting system must be designed accordingly. The most obvious solution is to have windows and skylights so that natural light floods the work area. If that's impossible (in basements, garages and interior rooms), a mixture of different fluorescent and incandescent lights might be the solution.

Shadow, Reflection, Contrast

One of the most vexing lighting assignments I had in art school was to place an egg on a white surface that also had a white background and, using a single photoflood lamp, light the egg so that there was complete definition of the egg and no bleeding of white from the egg to the surface or background. After more than a few hours, I thought that I had a workable scene. The problem was one of degree, too much or too little shadow, too much or not enough reflection and too much or too little contrast. Lighting focused straight on from the camera produced flat light; lighting from the side produced strong shadows; and diffuse lighting softened the image but at times produced no tonal separation. And all of these lighting setups were further changed if the light was close to or far from the subject.

tip

The amount of light required by a person to perform a task is directly related to age. At the age of 40, the requirement is three times greater than that for a 10-year-old. At the age of 60, the need is 15 times that for a 10-year-old.

Degrees Kelvin Ratings

DEGREES KELVIN

Daylight	5000 K
Incandescent lamp (tungsten)	2700 K
Blacklight lamp	4000 K
Warm white fluorescent lamp	3000 K
Cool white fluorescent lamp	4000 K
Daylight	5000 K
Photoflood lamp (tungsten)	3200 K
Photoflood lamp (daylight)	5000 K
Strobe light	5400 K
Daylight	5400 K
5000 K "fine" fluorescent lamp	5000 K
6500 K "fine" fluorescent lamp	6500 K

Degrees Kelvin is also useful if you are photographing your woodworking. The type of lights or strobes and film used will warm or cool the subject.

In the woodshop, the location, type and intensity of lights will produce a continuum of unacceptable and acceptable lighting conditions. Work area illumination requires careful light placement so that the area is shadow-free. Obviously it's possible to cover every square inch of ceiling with lights, but that's very inefficient. A better method is using the correct lights at their correct location. Flat lighting can be beneficial to a cabinetmaker wanting to see dovetail layout lines clearly. However, flat lighting isn't very useful for woodcarving. Lighting that is 45° to 90° to the carving will create better and more useful shadows that enhance the carving process. The texture and incisions from carving tools are very visible and the carver can use the shadows to enliven details.

If a carver knows the location and lighting conditions of the site a large carving will finally reside in, lights can be temporarily placed in the woodshop to duplicate that lighting. This preparation can spare the carver future problems. For example, a large statue of a Greek warrior will be permanently lit by two overhead spotlights. Knowing this, the carver can dramatize specific features, such as the helmet against the skin or the shape of a flowing cape. The carver can also shape facial features, such as the nose and eyebrows so that the face isn't ruined by ugly shadows.

Generally, it's best to locate light fixtures so that light falls directly over a work area. If there are numerous fluorescent lights throughout a work area, the diffuse light should limit shadowing. If, for example, there's a fluorescent light positioned above and behind someone at a workbench (or table saw), there will be shadows in the work area. This will occur even with the diffuse lighting of numerous fluorescent lights. To avoid this problem at the workbench, I have placed one double 8' fluo-rescent light fixture above the workbench and I have three double 8' fluorescent light fixtures positioned perpendicular to the work-bench and slightly behind and above the work side of the bench. These fixtures are approximately 5' apart and the ceiling height is 9'. The result is that I have diffuse, shadow-free lighting at the workbench. When I need more light intensity at the workbench, I clamp an incandescent Luxo articulated lamp on the corner of the workbench. This gives a spotlight effect, ideal for carving and seeing very fine drawing lines.



This is Earl Bartell's custom-made light stand with attached lamp. The base is heavy and sturdy enough to be used at any location.

Ceiling height, or the distance from the light to the work area, is also important. The general rule is that for any type of light (direct or diffuse, incandescent or fluorescent), the closer to the work area the stronger the shadows. The opposite is also true: The more distance between light and work area, the weaker the shadows.

Types of Lamps

There are three main types of lights for use in the woodshop: tungsten-filament lamps, halogen lamps and fluorescent lighting.

TUNGSTEN-FILAMENT BULBS Tungsten-filament bulbs are the most common bulbs found in homes. These are made of clear, frosted or tinted glass. Tungsten lamps are the most common lamps because their light is similar to the warm tone of natural light and because they have history on their side — this is the bulb that Edison invented. Tungsten bulbs are everywhere, and it's easy to change lighting conditions by simply replacing one bulb with another type of tungsten bulb. Clear

bulbs produce a bright and more contrasting type of lighting. Frosted bulbs produce a diffused lighting; tinted bulbs can add a diffused warmth to the environment. Spotlights and floodlights are also tungsten bulbs. These have body shapes and front lenses that either focus or diffuse the light. Generally, the beam angle is 15° to 25° for spotlights and 30° to 75° for floodlights.



In those locations that need more direct and less diffused light, I have replaced fluorescent lights with this type of halogen track lighting. This type of light gives a brilliant white light, lasts about three times longer and uses about 65% less energy than a standard incandescent light. This particular halogen light requires a 50-watt reflector bulb that is equivalent to the light of a standard 150-watt reflector bulb. It has a built-in transformer which converts 120V to 12V.

HALOGEN LAMPS What we refer to as halogen lamps are actually tungsten-halogen lamps. There are two basic halogen lamp types: low voltage and standard line voltage. Low-voltage halogen lamps require a transformer and operate at both lower voltage and lower wattage than standard line-voltage halogen lamps. They are usually designed as reflectors, allowing them to be directed at specific work areas. Low-voltage halogen lamps are relatively small and lend themselves to use in recessed fixtures. Generally, the beam angle from the reflector is 5° to 30°.

Standard line-voltage halogen lamps are more efficient than standard incandescent tungsten lamps, but they have the disadvantages of expense and high temperatures. Light fixtures must be capable of dissipating heat, and line-voltage halogen lamps should be kept away from any flammable materials — not a simple task in the woodshop. Recently, there have been safety notices regarding fires being started from certain styles of line-voltage halogen lamps, and screens have been made available for retrofitting on the lamp housing to keep cloth, paper and other flammable materials from touching the bulb. Furthermore, avoid touching the bulb with your bare hands because skin oil will affect the bulb and shorten its lifespan.

FLUORESCENT LAMPS There is a distinct division between home and commercial lighting: That is, most homes have tungsten lighting and most businesses use fluorescent lighting. The reasons for this difference are both historical and economical. Simplistically, houses have always been built and designed with incandescent lights as the principal lighting. What we can learn from commercial use is that fluorescent lighting is a source of low-cost, efficient, diffused lighting. As a dramatic comparison, tungsten bulbs have an average life of 750 to 1,250 hours; fluorescent lights have an average life of 20,000 hours.

Choose Your Lighting Carefully

It's expensive to illuminate a wood-shop, so carefully choose the best for yours.

- Use long-life, reduced-wattage bulbs whenever possible.
- If color is important, use bulbs that approximate daylight.
- Have zone lighting so that areas not in use can be unlit.
- Paint walls, ceiling and other surfaces such as pegboards, light colors.
- Use light colors for the maximum light reflection.
- Use incandescent spot lamps at drill press or band saw.
- Use droplights over workbench if you need more of a spotlight effect and less diffused light.

Fluorescent lamps are available in a variety of lengths, shapes and colors for any woodshop requirement. There are different color sensitivities, ranging from cool to warm white. Before purchasing the different varieties of fluorescent lights, make sure that the lamp and the fixture are compatible by checking the lamp's wattage with that of the ballast.

Poor-quality fluorescent lights have created a bad reputation for better quality fluorescent lights. Typical problems associated with low-quality fluorescent lights are leaking ballasts, humming or vibration noise and pulsing light. These are

generally not problems in better made units, at least not until they've been in service for very long periods.

One problem that occurs in woodshops is that of long boards reaching fluorescent lights. Lights above workbenches and table saws are often hit, showering the woodworker with glass particles. Avoid this by using clear plastic sleeves or tubes which fit fluorescent lamps. If the lamp is hit and breaks, the glass shards remain in the plastic sleeve.

TYPES OF FLUORESCENT LAMPS When shopping for fluorescent lamps, find a hardware or electrical supply store that stocks a full array of lamp types. There are at least eight different types of fluorescent lights. Store displays and product packaging should furnish lamp designations, including references to color rendering, degrees Kelvin, watts and lumens. Product names, such as “cool white” or “warm white,” are older designations. To comply with newer U.S. government standards regarding fluo-rescent lights, companies have had to redesign lights. Since the newer versions of “cool white” are different from the older products, newer product names were necessary. Hence, “Sunshine or SP-41.”

Typical Fluorescent Lights (48" tubes, GE products)

BULB NAME	°KELVIN	LUMENS*	WATTS	CRI**
Sunshine	5,000 K	2,250	40	90
Daylight Delux	6,500 K	2,250	40	84
SP-35, moderate white	3,500 K	3,200	40	73
Kitchen & Bath	3,000 K	3,200	40	70
Residential/Shoplight	4,100 K	3,150	40	72
SP-41, cool white	4,150 K	3,200	40	42

*Lumens is a unit of measurement that expresses the total quantity of light given off by a light source. For practical purposes, if comparing incandescent and fluorescent light, fluo-rescent lights use much less energy than incandescent bulbs and still produce similar or better light levels.

- 100-watt incandescent bulb is 1,710 lumens
- 75-watt incandescent bulb is 1,190 lumens
- 20-watt fluorescent light is 1,200 lumens
- 32-watt fluorescent light is 2,850 lumens
- 40-watt fluorescent light is 3,050 lumens

**Color rendering index (CRI) is a measurement of color shift when an object is illuminated by a light. CRI ranges from 1 to 100, with natural daylight and incandescent light equal to 100. Therefore, lights with a higher CRI produce more natural colors.

Note: Foot-candles is a measure of lumens per square foot, as measured on a working surface or floor area. For an office, the general working range is 15 to 70 foot-candles. If you are doing precise work, such as woodworking or drafting, 100 to 200 foot-candles is usually recommended. And if you think that is bright, on a cloudless sunny day, the sun gives off 1,000 foot-candles!

HIGH-INTENSITY-DISCHARGE LAMPS This lamp wasn't mentioned earlier because they are a fairly new type of lamp and are not commonly used. High-intensity-discharge (HID) lamps include metal halide lamps, mercury lamps and high-pressure sodium lamps. These have primarily been used for industrial purposes but are slowly being accepted for other uses (mostly for architectural and security purposes). There are disadvantages to using HID lamps: They require warming up and cooling down periods when they are turned on and off, and they produce a bluish light that gives an unfamiliar coloring to most things, including woodworking projects. Currently, the metal halide lamps are the only HID lamps that approach normal colorization. HID lamps, even though they are energy efficient, aren't useful for the woodshop because of their color rendering and fixture configuration.

chapter *nine*

Implementing Your Dust Collection System

If you are using machines and sanding materials for woodworking, then you are making a mixture of waste products: chunks of debris that fall in a large radius area and airborne particles which permeate the entire woodshop.

If you work exclusively with hand tools — hand saws, hand planes, chisels and scrapers — the principal waste will mostly be solid chunks deposited on the floor where you stand.

MANAGING SHOP WASTE

1. Remove floor debris with a broom or shop vacuum.
2. Capture machine-made dust and chips at the source with a dust collector.
3. Filter airborne particles with an air filtration system — or wear a filter mask.
4. Work in a wind tunnel so that all debris is blown out the door and into the neighbor's yard.
5. Ignore the problem and work in piles of chips and clouds of dust.

I have seen few totally chip-and-dust-free woodshops. Most woodworkers make some effort to remove most of the debris. Although many woodshops have some sort of dust collection system, very few have air filtration systems. And even with operational dust collectors, there is dust in most woodshops. Surprisingly, few woodworkers use filter masks, and I've even found several woodshops that rely on air flow from open doors and windows to minimize air-suspended particle dust.

There are many sizes and types of dust collectors and air filtration systems. There are readily available dust collectors powerful enough to have three separate 25'-long ductworks and to simultaneously remove debris from three separate machines. Additionally, there are many magazine articles detailing how to build everything from collector ductwork systems to air filtration systems. Over the past 10-plus years there has been considerable interest in the process of ductwork collection and air filtration.

Why are Woodshops Still Dusty?

The curious reasons why there are so many dusty woodshops:

- There are those who still don't care about the hazardous or unsafe nature of dust. It's a strange mind-set, based on a perception that since woodworking tools and machines make chips and dust, the woodworker should just let the stuff fall where it may. This false perception equates productivity with the amount of dust and chips on the floor (and everywhere else). The myth that a busy woodshop is a dusty woodshop still exists.
- Another erroneous notion about dust collection is that home woodshops don't have the same volumes of productivity as professional woodshops, hence there is less dust. The Occupational Safety and Health Administration (OSHA) has rules and standards for dust levels in commercial woodshops, and they have standards about air quality, safety equipment, proper installation of dust collectors and many other issues relating to the hazardous nature of dust because dust is unsafe. It is wrong to think that since the home woodshop is not regulated by OSHA, the need for proper dust management equipment isn't necessary.
- Collectors and filtration systems are not purchased because they aren't primary machines such as table saws or routers. Dust collectors don't directly help cut better edges or make better dovetails. It is also easy to think of dust collectors as something that we own but aren't overly enthusiastic about. Most woodworkers don't wake up in the morning thinking, "I can't wait to go to the woodshop and turn on the dust collector!"
- Dust collection systems aren't cheap. A basic dust collector costs from \$300 to \$1,000. 4"-diameter ductwork costs approximately \$2 to \$4 per foot. Fittings, such as elbows, reducers, shutoff gates and Y and T fittings cost \$10 to \$20 each, and replacement filter bags cost \$25 to \$75.
- Cost is often the only factor considered when purchasing a dust collector. There are numerous low-priced collectors that are popular simply because they are inexpensive. To be fair, some of these units probably are adequate if they only have 6' of hose and are hooked to a single machine. In order for manufacturers to make low-cost collectors they often simplify the collector's frame size, use low-quality impellers, include small-capacity filter bag sizes (and also use low-quality filter material), and install inexpensive (and lower hp) motors.
- Dust collection and air filtration systems are frequently either installed incorrectly or are inadequate for the volume of debris produced. Very often the technical specifications of dust collectors aren't well understood. It's critical to understand certain technical information when purchasing a dust collector.

DUST COLLECTION BASICS

There are a few noteworthy technical considerations specific to dust collection:

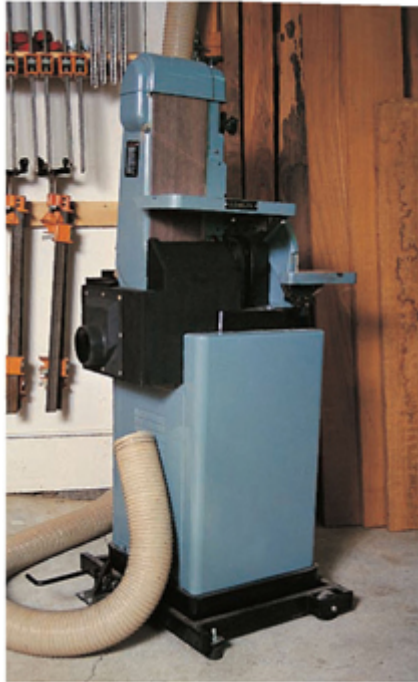
- SP (static pressure) is resistance to air in a ductwork and is measured in inches of water. Resistance is often referred to as friction.
- CFM (cubic feet per minute) is air volume.
- FPM (feet per minute) is air velocity.

The question is: How do you know if a dust collector is right for your woodshop, if it is installed correctly and if it can efficiently remove debris? Several important variables affect the performance of any collector:

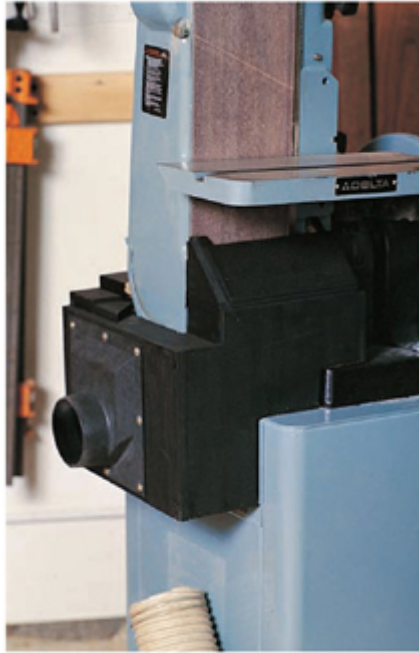
- technical specifications (hp and CFM)
- distance from the collector to a given machine (ductwork run)
- number of fittings
- smoothness within the ductwork system
- diameter of ductwork
- number of machines

Dust System Considerations

Dust collectors and air filtration systems need to be integrated into the entire woodshop. In fact, a case could be made that the dust collection system should be one of the first installations within a woodshop, and all machines and other features should be installed subsequently. Consider that when a new house is being constructed and the framing is finished, plumbing and electrical components are installed. Ideally, that is how dust collectors should be viewed. However, most woodworkers usually purchase a dust collector after they start generating mounds of debris from their machines. Then the dust collector is retrofitted to the woodshop.



In order to collect dust at the sanding machine, I built a plywood housing that encompasses both disc and belt sanding ports. The housing also encloses the belt beneath the table. Plastic fitting for the dust hose is available at most hardware stores.



Here is a close-up of the sanding machine's dust hose housing.



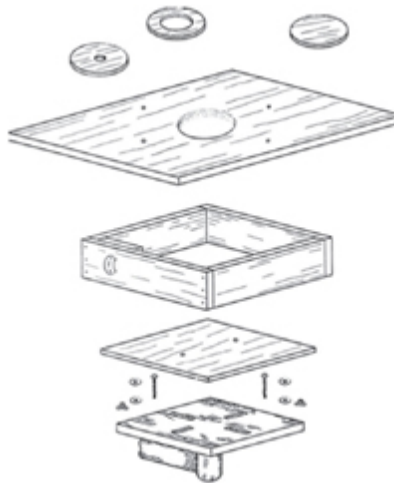
The drill press table in my woodshop features different table inserts for different-diameter sanding drums. The fence has a holder for a vacuum hose.



Here's the sanding drum lowered into the table; the vacuum hose is mounted on top of the table.



Here's the sanding drum lowered into the table and the vacuum hose mounted to the lower box.



This is an exploded view of the drill press table above: The frame has a hole for the vacuum hose. The top surface has a center hole with a rabbeted edge for the holding discs. The discs have different-size cutouts to accommodate sanding drums.

Very few machines are adequately designed for dust control. To make a dust

collection system functional, it must be fitted to machines so that all dust and chips are collected. This is a fundamental weakness of any woodshop collection system. Few factory machine hookups are efficient. It seems that manufacturers, in general, view dust collection as an after-thought. Consider the power tools that produce dispersed dust: planers, routers, all sanders, scroll saws, plate jointers and table saws. How many of these machines are designed with high-quality connections for dust collection? For example, an efficient table saw dust collection should have two collection areas: The area below the table should have a collection enclosure close to the saw blade, and there should also be collection above the saw blade, preferably integrated with the blade guard. Unfortunately, these features mostly exist on the more expensive table saws.

Most experienced woodworkers eventually construct collection hookups for their machines. Well-established woodshops often have all sorts of shop-made fittings and specialized hookups on machines. These are usually made of plywood or particleboard, and sometimes acrylic-type plastics, and they are characterized by form-fitting the machine's cutting area, dust chute or wood ejection area.

Locating the Dust Collection and Air Filtration Systems

As an analogy, most woodworkers locate dust collectors much like the antiquated houses that were built before indoor plumbing and electricity. When these new conveniences were first installed in houses, they were attached to the outside of walls. (Antique tool collectors now prize the hand planes used to make channels in moulding for the exterior attachment of electrical wires.) A modern person would never consider having electrical wires exposed and running around the outside of doors and moulding, nor having water pipes in a kitchen or bath. Yet, that same modern person will generally not think that retrofitted and exposed dust collection ductwork is inappropriate. I realize that there are many reasons for exposed ductwork systems:

- basement woodshops with concrete walls
- using portable collectors with short hoses
- ease in suspending ductwork from rafters (joists, etc.)• exposed ductwork is less expensive to install

New woodshops are being constructed that integrate ductwork systems into walls and under flooring. This approach requires the same mind-set that's used to install water pipes and electrical wiring. That is, there must be precise design planning of the system. Like an electrical circuit box or water heater, the dust collector must have a fixed location. This location should be somewhat removed from the general work area of the woodshop, and it should be accessible for cleaning. Furthermore, the number and location of machines should be determined prior to building the system.

I suppose it's reasonable to ask, "What's the gain of having a ductwork system built into walls and flooring?" The answer is that an internal ductwork system is

out of the way, and consequently, wall and floor space is freed up and made available for other uses. Most woodshops are small, and every visible surface is used for some sort of storage. Long expanses of 4"-diameter, horizontally mounted cylinders complicate the placement of cabinets, lumber storage, lighting and everything else required in the woodshop. Second, machines that are located in the central woodshop area and away from any wall create a complication regarding ductworks. For example, a table saw in an open area that is hooked up to an exposed ductwork system will have a ductwork or hose resting on the floor. This not only makes maneuvering large or heavy objects difficult, but walking over exposed ductwork is one hazardous step away from tripping.



John MacKenzie has underfloor dust collection ductwork.

Furthermore, the ductwork itself will eventually be damaged by being stepped on or by heavy objects falling on it. In fact, having ductwork or hose located below floor level for a table saw is enough of a justification for such a system. Of all the principal woodshop machinery, the table saw probably has the most awkward ductwork or hose arrangement. This is due to the fact that table saws have dust fittings at floor level, and the saws are generally situated in open areas, away from walls. When machines are located near walls, machines then have a back (unused) side, making it easier to install ductwork that is out of the way. It's also difficult to have ductworks and hose connections that drop from ceiling areas to the centrally located table saw. These perpendicular hoses will be in the way of lumber, and they create safety problems (the material being cut can bump into

the ductwork and back toward the blade and the operator).

Requirements for An Internal Dust Collection Ductwork System

- Existing woodshops may be impossible to retrofit with an internal dust system unless there is extensive remodeling or there is a sufficiently large underfloor crawl space. Ductwork is usually from 4" to 10" in diameter and this means that systems destined for walls, ceilings and floors require sufficient open areas to accommodate these dimensions.
- If walls are not to be remodeled, wood enclosures can be made so that ductworks are enclosed within. This wood box can be located either at the wall/ceiling interface or the wall/floor interface. At either location, the ductwork is enclosed and safe from bumps and damage. Furthermore, these wood enclosures can be easily integrated with cabinets and other storage units.
- Ductwork systems that include drop-downs from the ceiling area are somewhat easier to install if there is sufficient room above joists or there is attic space. Install metal ductwork systems similar to central heating and air conditioning ductworks. However, ductwork drop-downs in the middle of a room should always be considered a nuisance; that is, drop-downs probably will be in the way of other woodshop functions (moving lumber, etc.).
- In-the-floor ductwork has the most to offer in both usefulness and in the degree of difficulty in installation. If there is sufficient floor-to-ceiling height in the woodshop, the most straightforward solution is to construct a subfloor; that is, build a new floor above the existing floor so that there is space for the ductwork system. The new subfloor should be stoutly constructed to support the heavy loads of machines and lumber. The real bonus is that ductworks can be brought up through the floor next to a machine, or even within a machine's cavity. This minimizes tripping over and/or bumping ducts and hoses.

If a new woodshop is being constructed with concrete floors, there are several considerations for ductwork below the floor. The basic room design must include adequate floor thickness and floor-to-ceiling height. Ductwork channels must be created with forms and poured cement. Instead of a single continuous floor surface, it will be necessary to carefully pour cement in different areas between forms and to ensure those areas are flat and true to each other. Once the concrete is hard, ductwork is placed in these channels and the open channel is then covered with wood, brick or concrete blocks.

The very nature of woodshop design is constant change and the incorporation of new ideas, products and evolution. Although the marketplace is now filled with a variety of similar dust collectors, the use and setup of those dust collectors is changing. It wasn't that long ago that few woodshops had any dust collection whatsoever. Now we are using dust collection systems and are attempting to

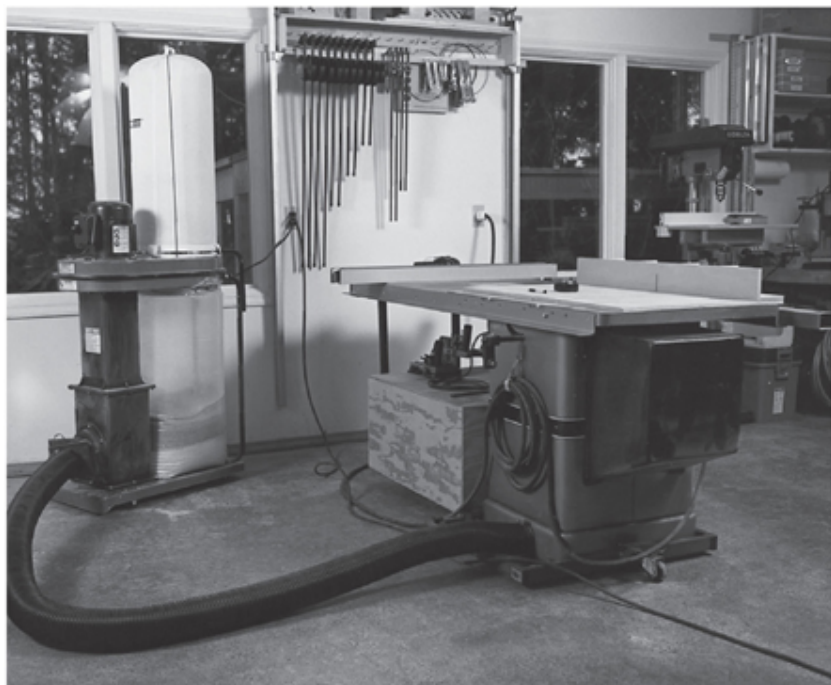
customize them to our individual woodshops. Presently, it may be adequate to use dust collectors in the familiar way, using metal ductwork attached to walls and ceilings with a short length of flexible hose attached to a machine. In the near future, more and more woodshops will be set up with more efficient ductwork systems hidden in walls, ceilings and floors. Just as there was no interest in air filtration systems 20 years ago, the integrated ductwork system will undoubtedly be part of future woodshops.

SETTING UP DUST COLLECTION AND AIR FILTRATION SYSTEMS

Gather Information

Use magazine advertisements as the first source of information, and request technical information from the manufacturers and retailers that supply the collection and filtration systems. Request information about dust collectors, filtration systems, ductwork, flexible hose, remote on/off devices, high-efficiency filter bags and grounding kits. Once you have gathered your information, make comparison charts that include:

- model
- motor hp
- motor repair service location
- amperes
- voltage
- CFM (maximum)
- static pressure
- dBA at 5 ft. (dBA is a unit of measurement that expresses the relative intensity of sound. The least-perceptible sound to pain-level sound ranges from 0 to about 130 dBA.)
- hose-diameter hookup at collector
- number of hose outlets on collector
- bag capacity
- type of bag material (traps what micron size of dust particles?)
 - drum size
- cost of basic unit
- cost of add-on accessories



This table saw has a portable dust-collector hookup. Jon Magill plans on replacing this stiff hose with a more flexible type. He works with one machine at a time and he isn't bothered by moving the dust collector to another machine when changing operations.

Choose a Type

There are three basic types of dust collectors: single-stage, two-stage and cyclone. Each type will collect dust. Aside from design differences, the main considerations for choosing which type to use are the number of machines and amount of dust and debris created, length of ductwork, ease of removing captured waste from bags or barrels, noise level and cost.

SINGLE-STAGE DUST COLLECTORS Single-stage collectors are visually characterized by having two or four filter bags. The bottom bags collect larger debris, and the top bags filter the finer dust and return air back into the woodshop. This type is usually the most portable and affordable in the marketplace. There are two common drawbacks to the single-stage collector, both of which are easily remedied. It is often stated that, because the debris travels directly through the impeller housing, there is unnecessary wear on parts. Manufacturers of better-quality units often make heavy-duty impellers or design the impeller so that a bent fin can be easily replaced. Optionally, an in-line separator can be installed before the collector in order to separate out larger debris. These inexpensive units are installed between the woodworking machine and the dust collector. They simply replace the lid on a garbage can. Chips are then deflected via baffles into

the garbage can and only very small debris and dust continues through to the main dust collector.

I have used this style with four bags for over 15 years and have never had mechanical problems. However, I strongly recommend that no large wood fragments or cutoff pieces be vacuumed into the impeller — that would probably cause damage. I don't have a floor sweep, a floor-level debris pickup attachment, connected to the system because I don't want large, heavy objects zooming through the ductwork and slamming into the spinning impeller. The second serious drawback of the single-stage collector is the blowing of fine dust through the filter bags and back into the woodshop. The filter bags that come with most collectors are porous enough to allow fine dust through the bag weave. As a consequence, larger debris is caught in the bags and fine dust migrates throughout the woodshop, creating unpleasant and unnecessary air pollution. Replacement filter bags that filter down to 1 micron particle size are recommended.



Doug Matthews keeps his dust collector tucked behind an unfinished interior wall. The planer and jointer are easily hooked up to the collector when they are used. Note how he has also used this area for clamp storage.

TWO-STAGE DUST COLLECTORS Two-stage collectors are characterized by a blower motor on top of a collector drum (35 or 55 gallons) with a sidemounted filter bag. Generally this type is mounted on wheels. These are designed so that larger debris settles into the drum, and fine dust is captured in the filter bag. The significant drawback is that the motor housing is heavy and it has to be lifted off in order to empty the collector drum (which is also heavy when it's full). This is a tiresome process, especially if you need to frequently empty the drum. Those that use this type often use ropes and pulleys to raise the housing off the drum.

CYCLONE DUST COLLECTORS Cyclone collectors appear to be industrial; it's a tall steel cylinder with a funneled midsection and a 35- or 55-gallon collector drum. Debris enters the upper chamber and is cyclonically separated. Larger debris spirals downward into the collection drum, and the fine dust is caught in filters located within or near the cyclone unit. The exterior filters, called shaker bags, are a series of tall, thin bags, that effectively trap dust particles and filter the exiting air. Most of the cyclone units are fairly quiet when operating. This is due in part to having a muffler for quieting the exiting air. Interestingly, there are two types of cyclone systems: commercially made units and do-it-yourself units (*WOOD Magazine*, Issue 100, November 1997).

Stay Within Code

Check local building codes concerning the placement of collectors. Certain types of collectors may need to be located outside of the main woodshop.

Lay Out Your System

Draw a layout for your woodshop. Locate the collector so that it's out of the way without requiring unnecessary ductwork lengths. As a reference, consider the vein pattern in a leaf. Determine the length of the ductwork, the number of fittings (elbows, etc.) and the diameter of the ductwork.



The Oneida cyclone dust collector, shown above in Charles Caswell's shop, has the air filter within the cyclone. It also features a muffler (protruding horizontally just below the motor), 5" ductwork, 35-gallon fiber barrel and a remote on/off switch located on the combination machine.



For this cyclone dust collector, the filter bags are suspended in a closet. The cyclone unit is located outside of the woodshop, behind the closed door, visible through the window.

Typical Air Flow Requirements for Various Machines

MACHINE

300-350

300-350

300-350

350-400

400-450

350-400

350-400

CFM Requirements for Duct Diameters

DUCT DIAMETER

370

300

375

Static Pressure by Duct Diameter

DUCT DIAMETER PRESSURE*

3/5

3/5

3/2

3/5

*3,500 FPM per 100' of duct

Note that the length of ductwork and its internal smoothness, as well as the shape and number of fittings, all increase frictional resistance to air flow. Any

internal friction and/or air turbulence decreases collection efficiency.

Ducts and fittings that have gradual directional changes will help make a system more efficient. Avoid ductwork runs having abrupt angles or turns. If possible, avoid using 90° T fittings; instead, use 45° to minimize turbulence. If different diameters are required, use tapered connectors for smoother transitions between the ductworks.

Companies such as Air Handling Systems by Manufacturers Service Co., Delta Machinery Corp. and Oneida Air Systems, Inc., all provide excellent information regarding how to determine CFM for the system, ductwork air velocity, system resistance, and the proper size of ductworks and fittings. If you send Oneida Air Systems a blueprint of your woodshop, they will design the correct duct-work for your woodshop — free.

Consider Your Needs

The diameter of the ductwork will affect air flow. Wood dust requires a minimum velocity of 3,500 FPM within the main ductwork or debris can settle out of the airstream, leading to blockage problems. The two variables that relate to ductwork diameter are velocity and static pressure. Larger-diameter ductwork increases static pressure and reduces air velocity; as ductwork diameter decreases, static pressure decreases and air velocity increases. The main consideration is to minimize static pressure loss. To accomplish this you must measure each ductwork run; that is, the length from the machine to the collector. Also, each fitting causes a reduction in air velocity, so fittings must also be factored into the length measurement. The common practice is to assign an equivalent length for a fitting. For example, a 90° elbow is equivalent to 6' of duct, or a 45° elbow is equivalent to 3' of duct. Therefore, a ductwork run that consists of 20' of straight 4" ductwork, three 90° elbows and one 45° elbow is equivalent to 41' of ductwork.

To use this value, there is another step to calculate the actual static pressure for the ductwork run. Static pressure is usually based upon 100' of ductwork. 4"- and 5"-diameter ductwork are the most commonly used sizes.

For the example of 41', multiply 0.41 (41' of 100') by 5.5, equaling 2.55" of static pressure ("inches of water"). If the filter bags are dirty, an additional static pressure loss should also be added to the value. As a generalization, add a value of 1, thus equaling 3.55". Note: This is for one ductwork run without any branch runs. If several machines are hooked up to the collector but are operated one at a time, the ductwork diameter will be dependent on the machine with the greatest CFM requirement.

If you are creating a complicated network of ductwork and fittings, careful calculations of ductwork length and all fittings is required. Determine the static pressure value for the entire system and compare that value with those of the various dust collectors in the marketplace. This value isn't absolute: there are a number of factors that influence the actual rating. Air leaks, ductwork crimps and

rivets, ductwork interior smoothness, corrugated flex hose, dirty filter bags and machine hookup attachments are only a few of the variables influencing dust collector efficiency.

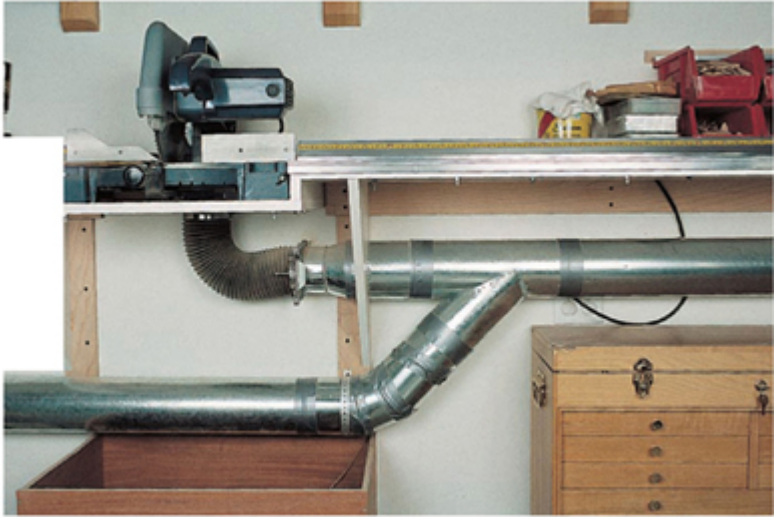
Metal Ductwork

Metal ductwork is slightly more difficult to install than plastic (PVC) pipe, but it is easier to ground against static electricity. Oneida Air Systems recommends using 26- to 24-gauge, or heavier, galvanized straight pipe for small custom woodshops. Heating and ventilation ductwork (usually 30 gauge) is too thin for dust collection because it can be easily dented. This causes disruption in the air flow; also the thin walls can collapse under dust collector fan pressure.

Flex hose should be used for connecting metal ductwork to a machine. Keep the lengths to a minimum because of the increased air resistance within the uneven hose.

Plastic Pipe

The common method for grounding plastic pipe is to run a ground wire inside the entire length of the pipe and then attach it at either end to the machine and the earth ground. The disadvantage of this method is that wood debris can break the internal wire unbeknownst to the operator. Debris can also lodge around the wire and eventually cause a blockage. I won't use plastic pipe because static electrical charges build up as dust travels rapidly through it — and airborne dust has the potential to be highly combustible. I talked with one woodworker who thought he had done all the correct hookups and grounding for using plastic pipe. Yet, late one night, when no one was using the woodshop, there was a static discharge within the pipe which sparked into residual dust and his woodshop was lost to fire. Another person told me his story of attempting to add more PVC pipe to an existing system. The PVC pipe was grounded and the system was off. When he hand sawed into the pipe, there was a static discharge powerful enough that it knocked him across the room.



Tidy metal ductwork. There's a blast gate at the flex hose to the chop saw with the other duct going to the combination machine in the Caswell woodshop.

AIR FILTRATION

Air filtration is perhaps one of the most important features that relate to a woodworker's health. Fine dust particles will stay in air suspension for hours. These particles are so small that they are almost invisible. However, a person in the woodshop will breathe these particles into the nasal and throat passages and lungs. There is much evidence as to the health risks of breathing dust, so the ideal woodshop should have a method of removing these particles. As a doctor woodworking friend once said, "You don't breathe the large chips that settle out on the floor, you breathe the tiny airborne particles that you can't see."

I had numerous woodworkers tell me they think that their woodshops got dustier after they installed dust collectors. So, the first thing to do before using a new dust collector is to make the dust collection system free of dust leakage. Leakage can occur at the machine and the filter bags. Well-fit hookups at the machine are mandatory. If the machine's factory-made hookup seems inadequate, make your own. Second, most dust collection bags are susceptible to dust migrating through the fibrous weavings. Most standard-issue bags capture dust sizes of 10 to 50 microns; smaller sizes escape back into the woodshop environment. The best solution is to check with the dust collector manufacturer about replacing the bags with high-efficiency filter bags, which will filter particles down to 1 micron in size.

Air filtration units are also becoming popular. These units are hung from the ceiling in the room's air circulation pattern and filter the air. By using a continuous-duty fan and a series of filters, very fine airborne dust (1 to 5 microns) is trapped and clean air is circulated back into the woodshop. The air filtration

unit is not meant to be a dust collector. Rather, its purpose is solely to filter the finest dust from the air. Commercially made units cost approximately \$250 to \$700. However, it's fairly easy to make your own air filtration unit by building a plywood box (approximate size would be 12" × 24" × 36") and installing a furnace-type fan (¼ hp) with several high-quality slide-in furnace type filters. Carbon filters can be added to the air filtration unit so that fumes and odors are also filtered out of the woodshop.

Plastic Pipe Guidelines

If you are determined to use plastic pipe for dust collection because "Old George at your woodworkers' club uses it," you should at least do the following:

1. Ground the pipe by installing a taut ground wire inside of it.
2. Also ground the plastic pipe by wrapping a ground wire spirally around the outside of it. Both types of grounding should be done to all pipes in the system, and the wires should be properly attached at either end to machines and a proper ground location.
3. Assemble the plastic pipes so that they can be unassembled for cleaning out chip blockages (use pipe connectors and ductwork tape).
4. Occasionally check for any internal blockage and for continuity in the internal ground wire (look for chip buildup around the wire and for wire abrasion).

The ideal solution for dust collection, especially if your woodshop is attached to your house, is to have an efficient unit that is both quiet and powerful enough to use with several machines operating. For most woodshops, suspend metal ductwork from the ceiling and make certain that the ducts are properly sealed, free of leaks and properly grounded against static electricity buildup. The hookup fittings should be well made and fit tightly on the machines. The dust collector should have high-efficiency filter bags and a manageable system for removing the drums or bags when they are filled. Finally, an air filtration unit should be hung from the ceiling so that fine dust is also captured. If that doesn't make a dust-free woodshop, open a window and the door.

Accessories

I suppose that anything purchased separately from the basic dust collector is considered an accessory. But several noteworthy items will definitely improve dust collectors. Check for availability — or adaptability — with specific models of dust collectors. Accessories include:

- high-quality filtration bags — look at the specifications of these bags and be certain they offer at least a 99% efficiency in filtering 1-micron particles
- in-line separator — this item is installed between a machine and dust collector and looks like a garbage can lid; it has no moving parts and simply sits on a standard garbage can; an inexpensive improvement for most dust collection systems
- positionable vacuum hose — Lockwood Products makes the Loc-Line vacuum hose, a nifty articulated self-supporting (up to 3') ball-and-socket type of hose that is ideal for dust pickup at the drill press or the router table; a 2½" vacuum hose — the typical shop vacuum; the Loc-Line system has many different fittings, including both a round and a rectangular nozzle, slide valve (blast-gate), 3" PVC adapter and shop vacuum adapter
- automatic blast-gates — Ecogate manufactures a system of computerized blast-gates that automatically open or close when a machine is either turned on or off; control box allows you to set the sensitivity of the sensors, and can be programmed to keep one or more gates open; this system reduces the time of manually working blast-gates, saves electrical energy and actually assists in woodshop cleanliness; plus, not a complicated installation



Here is a Delta air cleaner suspended from a ceiling.



A small blower fan is used to vent the shop of very fine airborne dust.

A TYPICAL DUST COLLECTION SYSTEM

The most confusing aspect of setting up a dust collection system is understanding the relationships of air volume or CFM (air measured in cubic feet per minute) and static pressure (the resistance to air at rest in a ductwork) to the length and diameter of ductwork and the number of machines in the woodshop.

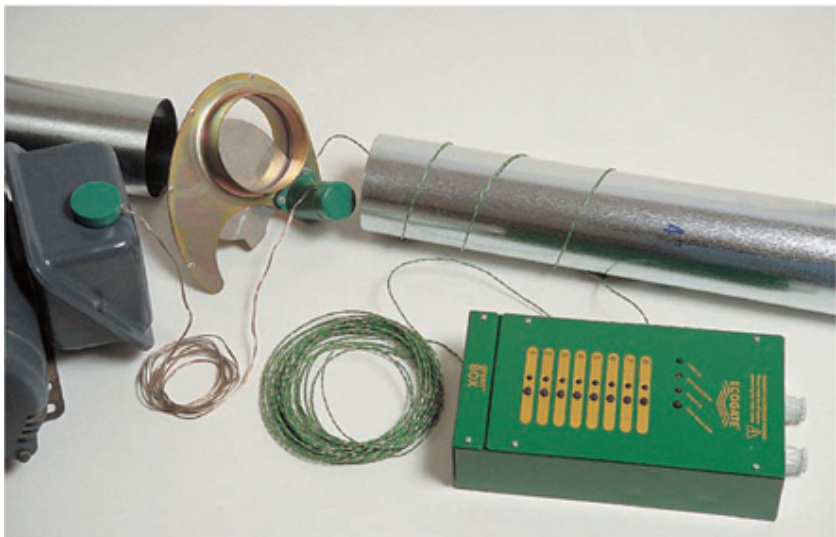
Let's assume that your woodshop is in either a garage or basement and you are the only person operating machinery. Your plan is to connect the dust collection system to a table saw, band saw, jointer, planer, disc/belt sander, lathe and drill press:

1. After you have reviewed the specifications of all potential dust collectors, select the one that has the greatest horsepower (at least 1½ to 3 hp) and is rated greater than 700 CFM at 5" to 6" of static pressure. For example:
 - Grizzly model G1029, 2 hp, 1,182 CFM at 5.00" of static pressure
 - Oneida air blower, 2 hp, 900 CFM at 8.00" of static pressure

- Delta model 50-181, 2 hp, 1,100 CFM at 8.50" of static pressure
 - Bridgewood BW-003, 3 hp, 1,950 CFM at 5.80" of static pressure
 - Oneida air blower, 3 hp, 1,350 CFM at 8.00" of static pressure
2. Determine the filter bag area. Typical bag sizes range from 10 to 40 square feet. As a guide, have at least 1 square foot of filter bag area for every 10 CFM. For example, a 10 square foot filter bag is useful for a 1,000 CFM collector. If the filter bag area is less than the rated CFM, install larger bags.
 3. Install metal 6" and 5" main duct-work going out from the collector. Generally, 6"-diameter ductwork is used nearest the collector and then it's reduced to a 5"-diameter ductwork further from the collector.
 4. Please don't use plastic pipes. Plastic pipes can be dangerous because of the significant static electricity charges that are generated when air, wood dust and chips travel through the pipes.
 5. Securely assemble the ductwork system with pop rivets, sheet-metal screws or ductwork tape. Seal all ductwork with silicone sealer, and be sure there are no small openings or cracks, which cause air loss.
 6. Minimize the use of elbows and turns. Use large-radius elbows when branching off of the main ductwork to the individual machines; don't use 90° T fittings. Also, use 45° Y fittings for any turns off of the main ductwork line. If it's necessary to use smaller diameter hose, use reducer fittings on the machine side of the elbows. Use metal ductworks up to within approximately 3' of the machine. Then, use flexible hose as the 3' connector to the machine. Properly ground the flexible hose by wrapping the ground wire around the hose and attaching one end to the metal ductwork and the other to ground.
 7. Use gates (blast-gates) at all machines to control air to each machine. Place the gate between the metal ductwork and the flexiblehose.
 - When using the dust collection system, keep blast-gates closed at unused machines.
 - If the dust collector is in an out-of-the-way location, install a remote control device for wireless on/off operation. These units are available from most sellers of dust collectors.



The Loc-Line flexi-ble vacuum line (2½" I.D.) is self-supporting — to approximately 36" — and with an adapter fits the 2¼" connector hose hole of a shop vacuum. This is a long overdue solution for collecting dust at the drill press or other machines that don't have built-in collector capabilities. Shown are 36" of Loc-Line, the 4½" round nozzle and the 6" × 3½" rectangular nozzle. Various other accessories are available, including a 3" sheet-metal duct adapter.



The Ecogate electronic blast-gate has sensors to detect which gate to automatically open or close when debris is moving within the ductwork, thus saving the operator time, and lowering electrical operation costs. I have laid out the basic configuration (from left to right): a woodworking machine motor, sensor pad with wiring to the Ecogate, ductwork with the spirally wrapped connector wire from the gate to the electronic control box.

Wood Toxicity Safety Guidelines

- Always wear some form of face mask or respirator. Disposable masks are often form-fit around the nose and mouth; reusable respirators have replaceable filter cartridges. If these are inadequate for your needs, there are space-age-looking air purifying respirators. These have a hard hat with a clear plastic face shield. The shield formfits the entire face, and at the back of the hard hat is a fan unit that blows filtered air over the top of the head and down across the face. Note that you are breathing filtered air — and not breathing through a filter. While these units are expensive, they offer features not found in standard filter masks, such as full-face protection from flying debris (they are popular with lathe turners) and comfort for woodworkers with beards or eyeglasses (standard filter masks and respirators don't fit well on beards and under eyeglasses).
- Wear long-sleeved shirts to keep dust off your arms. Don't wear loose or unbuttoned shirts because loose clothes and machinery are a disaster waiting to happen. Longsleeved T-shirts are a better choice.
- If you are sanding, create air circulation away from the work area. Place a portable fan at one end of the workbench and sand at the other end. The fan should blow dust away from you.

CONSIDER WOOD TOXICITY

Perhaps after the discussion of machines and collectors, there is another topic that needs to be mentioned — toxic woods. While dust collectors will remove the

majority of dust and chips, it is inevitable that some dust is going to fall on your skin and be breathed into your lungs.

Sometimes I think that working with wood is like having a tiger for a pet — it looks great, but it can bite your hand off. While everyone has different sensitivity levels, wood is known to cause skin and eye allergies as well as respiratory and cardiac problems. Some woods are classified as primary irritants because they are highly toxic (West Indian satinwood, for example). Other woods are classified as sensitizers because they may cause physical reactions after repeated exposures (such as cocobolo).

One of the toxic conditions that is often difficult, if not impossible, for consumers to know about is wood contaminated with pesticides and preservatives. Treated lumber in the United States is labeled as such, and the manufacturers post handling guidelines for their products. Unfortunately, while there are many chemicals banned from use in the United States, those chemicals are often used by foreign companies with no posted notices or guidelines.

If you have questions about wood toxicity, consult your own physician, the Occupational Safety and Health Administration (OSHA), your local city health department, and/or textbooks on poisonous plants.

A Partial Listing of Woods and Their Potential Hazards

REMOVAL LOCATION*[illegible]

Respiratory, Skin, Eyes
 Respiratory, Skin, Eyes
 Respiratory, skin, eyes
 Nausea, malaise
 Respiratory
 Respiratory, skin, eyes
 Skin, eyes, black
 Respiratory, skin, eyes
 Nausea, malaise
 Nausea, malaise, cardiac
 Skin, eyes

*This does not represent the order in which any ailments or problems occur. This information on wood toxicity is from "Health Hazards in Woodworking" by Stanley N. Wellborn, Fine Woodworking, Winter 1977, American Woodturner, June 1990.

chapter ten

Creating Useful Storage Space

WHY STORE STUFF AT ALL? I'VE never been certain about the concept behind the need for storage. Do we store things for organizational reasons, for clutter control, for easy access or simply because we have too much stuff? Ideally, any part, accessory or tool should be within reach during the work process. Realistically, however, everyone has shelves, cabinets, drawers, walls, hangers, rafters, bins, boxes, barrels, racks and trunks full of the useful, rare, odd and ordinary. We usually have favorite tools stored individually at arm's length, and everything else is put away. Diet books and storage books have something in common — sheer numbers. There are hundreds of books, magazines and videos offering every conceivable solution to taming the flotsam and jetsam — or the delicate and valuable objects — of our lives. And one more point: Woodworkers make objects. We either make artistic objects or we make cabinets, shelves, drawers or boxes for storing and displaying everything and anything.

Woodworkers are collectors. We collect everything that seems useful, and we justify our collecting with the rationale that we need it — or will need it someday. It always sounds reasonable to say, “I need a complete set of brad-point drill bits, including $\frac{9}{64}$ ” and $\frac{7}{32}$ ”. Realistically, you may only need $\frac{1}{4}$ ”, $\frac{3}{8}$ ” and $\frac{1}{2}$ ” brad-point bits, but there's always the uncertainty that leads you to believe that a set of 12 bits is necessary. Besides, the tool catalogs enthusiastically declare that having a set of 12 bits is invaluable.

In addition to collecting extras of any given object, woodworkers also collect interesting tools, wood, information (books, magazines and plans), accessories, gadgets and finishing products. We generally obtain these items as if space and storage aren't of any concern. We don't just have one of anything; we like sets and collections so much that we go on quests to complete a particular set. We specialize in our tools and things so much that we become experts on the rare and unusual. We join clubs devoted to antique tools or wood samples. We track down obscure and out-of-the-way dealers in order to possess hard-to-find Stanley Bedrock planes or pieces of Pink Ivory. No one should doubt that woodworkers are at the center of the storage issue as both creators and users.



Here's a view of clamp storage in my woodshop. The upper 4" × 4" beam has an angled face so that clamps are suspended at an angle. Shorter bar clamps are suspended from ½" metal dowels inserted into a secured 2" × 4" board.

Types of Woodshop Storage

- Floor-level and wall-hung cabinets
- Modular, freestanding cabinets
- Portable units
- Shelving
- Pegboard
- Lumber storage

ORGANIZE SHOP STORAGE

After you have established the locations of machines and the workbench within the woodshop space, it's time to organize storage. If the room is built and the

machines are in place, start by standing near each machine and imagining what work will be like and what tools and accessories might be needed while working. Determine the needs for all machines and then make a master list for the entire woodshop.

An example list might include:

Table Saw

- three saw blades
- tenon jig
- push sticks
- miter guide
- featherboard
- angle fence
- dado set

Band Saw

- five blades
- circle cutter
- miter guide
- fence

Planer

- dial indicator
- spare knives
- table wax

Drill Press

- drill index
- multispur bits
- sanding drum set
- extra-length bits



Three types of storage are shown in the above photo: cabinet storage for the drill press, pegboard storage for infrequently used accessories and workbench shelf storage for frequently used tools.

Consider Your Options

Once the list is completed, consider storage options: shelves, open wall hangers, open cabinets, closed cabinets, drawers and so on. Then ask yourself, is one or more storage units necessary? Is there a need for one local storage center, or does each machine need its own storage? Note those tools, such as a dial indicator, that should be kept dust-free and those tools unaffected by dust (band saw blades). Also, drill bits are easily lost in clutter; they are best kept in orderly sets.

DESIGN STORAGE SPACE

The next planning step is extremely critical to the overall shop plan. Basically, two very different designs can be selected, and each will fundamentally affect the woodshop. The choice is that of having randomly designed storage or having unified storage.

Random Storage

Random storage is characterized by what is generally done: a hodgepodge of shelves, pegboard, hooks, hangers, cans and cabinets. Unified storage is exemplified by cabinets similar to those found in kitchens, baths and design books. Most woodshops have random storage because new things are added over

long periods of time. Interestingly, hodgepodge storage doesn't mean that things can't be found. After a while, most woodworkers know where they stored the No. 8 brass roundhead screws. It all becomes second nature. Unfortunately, despite the fact that they are inefficient, waste space and are usually covered with thick layers of dust — shelves are still the most common storage arrangement.



Here's an inside view of the drill press cabinet shown in the top photo.



Harry Charowsky swears he knows where everything is in his random tool storage system.

Unified Storage

Unified woodshop storage should, at its essence, maximize the available space or area allotted for storage. This can be accomplished by designing storage units so that there are no dead areas. For example, instead of making a 5'-high cabinet, make it floor-to-ceiling and use the upper shelves for infrequently used items. Or construct European-style cabinets because they have less wasted internal space. Design a mixture of storage types so that they complement each other. Have a cabinet, for example, for storing hand planes. And next to the cabinet use pegboard for hanging hammers and yardsticks.



Simple dividers keep small hand planes from rubbing and bumping.



A thin board (1/8") with attached dividers separates chisels and isolates the cutting edges.



Use a thin drawer to store all the screws, collets, plates and other small items used with routers. By lining the tray with fuzzy felt, the numerous small items don't migrate in the tray.

MATERIALS AND STORAGE DESIGN

The design of storage units will be influenced by the type of materials used. Solid-wood construction procedures will be different than those needed for working man-made materials.

Solid-Wood Construction

If solid-wood constructions are desired, a number of woodworking tools and skills are required. For example, suppose you want to build a Shaker-style wall cabinet. The following are the generalized steps needed to duplicate or simulate this early-1800s construction:

1. Purchase rough lumber approximately 1" to 1½" in thickness. Allow for waste, and order 20% to 30% more than the project requires. Typical woods are pine, cherry and oak.
2. Plane lumber to different thicknesses, varying from 5/8" to 1".
3. Use a hand plane or joiner to square and straighten edges.
4. Glue boards edge to edge to make wider pieces.
5. Construct the basic cabinet box using joinery: traditional dovetails or modern joints, such as box joints, plate joinery, dowels or screws.
6. Construct internal framework consisting of different sizes of wood. Use hand tools or a router to make rabbets and sliding dovetail-type joints.

7. Construct frame and panel doors consisting of tongue-and-groove and mortise-and-tenon joinery. Use chisels, saw, hand planes, router table or shaper.
8. Construct drawers with dovetail joints. Use hand tools, a router and a dovetail jig.
9. Fit doors and drawers to cabinet so that seasonal weather changes won't cause them to stick, bind or be too loose fitting.

Using Man-Made Materials

In contrast, the construction of a modern cabinet using man-made materials follows a different set of steps.

1. Purchase $\frac{1}{2}$ "- and $\frac{3}{4}$ "-thick materials. Itemize cutting list and purchase necessary amount of materials. Typical materials are particleboard and medium-density fiberboard (MDF).
2. Cut materials to size.
3. Assemble materials with butt or rabbet joints. Use a router, plate joinery, screws and nails.
4. Cover exposed edges with veneer-type tape or strips of solid wood.
5. Use either face-frame or the frameless European cabinet construction for the front of the cabinet.
6. Construct drawers with dados and grooves. Use a router, screws or nails.

CABINET CONSTRUCTION

Most modern cabinet constructions use a blend of man-made materials and solid wood. It's common to see cabinets that have plywood sides, top, bottom and shelves, and solidwood doors, door frame and drawer fronts.

Face-Frame Cabinets

Typically, the face-frame cabinet has a 2"-wide frame covering the front edge of the cabinet. The frame thus reduces the size of the cabinet opening, with doors and drawers smaller than the cabinet width. Doors are typically attached to the frame with exposed hinges; drawer fronts usually overlap onto the frame. The toe space at the cabinet's base is made by cutting notches into the side pieces.

European-Style Cabinets

The frameless or European cabinet has no face frame. Instead, the front edges are

covered to the same width as the cabinet box material thickness. Doors and drawers are usually flush to the cabinet edges and each other. That means more usable interior space. European cabinets are sometimes referred to as “the 32 millimeter system” because of the standardization of using 32 millimeters as the space between hinge fittings, shelf-support holes and cabinet joints. Frameless cabinets are generally made as a box and then attached to a separate base frame. This allows for the toe space as well as different height bases.

DO IT YOURSELF OR NOT?

It's an old saying that woodworkers should build their own woodshop cabinets and benches in order to understand, practice and refine their various woodworking skills. While there is nothing wrong with this viewpoint, I would like to offer an update on this old saying by breaking it down into various elements, somewhat like a logic puzzle. Ponder the following thoughts and questions.

1. Is building storage cabinets for the woodshop really a preparation for using the woodshop?
2. If you are an amateur or hobby woodworker, how much time do you have to devote to woodworking?
3. Is cost-effectiveness an issue?
4. What machines and tools are available for building storage?
5. How will you transport materials?
6. Is the location for storage unusual, unique or average (i.e., the need for special or standard-size storage)?
7. What will you learn about woodworking by cutting plywood, particleboard and drilling holes?
8. Can you make it the same as, or better than, commercial storage units?
9. Is the woodworking process (including making storage units) one of self-expression, personal enrichment and an element of quality of life?
10. Do you have the space for working with sheet goods?
11. Do you have the physical strength for handling full-size sheets of $\frac{3}{4}$ "-thick plywood?
12. Is making everything in the woodshop a rite of passage?

Consider Time and Money

It's not easy to answer each of these questions with a simple response. However, a

few parts are very real; that is, time and money. Very often it takes considerable time to design, purchase materials, build and install cabinets and other storage units. We may watch someone on TV build a cabinet during a 30-minute program, but I can assure you that real life woodworking takes significantly longer. Ask yourself, "How much is my free time worth?"

Don't Dismiss Purchasing Storage Units

I appreciate the love affair with working wood. The magic of taking a raw material and turning it into personal and useful objects is something I never tire of. At the same time, I realize home improvement centers sell cabinets and storage units at very affordable prices. In fact, it is often less expensive to purchase these units than it is to build them. For example, I recently looked at a 36"-wide by 12"-deep by 72"-tall cabinet that had two doors and adjustable shelving. The cost was under \$100. That's a persuasive argument for not "doing-it-yourself"!



Built-in workbench with open storage area. Plastic containers are used for holding odds and ends.

Of course, there are very real, legitimate reasons to buy and use off-the-shelf storage units. An incredible variety of these units are sold at home improvement centers, including wire shelves and bins, airtight plastic containers, tall cabinets with shelves and doors, and drawer units. They are designed for bedrooms, dens, laundry rooms, kitchens and garages, and most are adaptable for woodshop applications. These units usually come in flat boxes, and you assemble the units at home. I'm impressed with bedroom closet storage units because they often are composed of smaller drawers and many small cubicles and are designed to cover

entire walls. These are the features that would adapt to a woodshop (glue bottles would fit nicely into a shirt cubicle and tie racks could hold sanding belts or extension cords). Besides being affordable, ready-made storage offers a simplicity that's valuable, especially if you're just starting out in woodworking and are not equipped to work with large sheets of particleboard and plywood.

BUILDING SHOP STORAGE

Basic storage units are shelves, wall hooks and hangers, bookcase-style open cabinets, racks and cabinets with shelves, drawers and doors. Wall-hung devices and shelves are inexpensive and easily installed; cabinets require more materials, construction skills and machinery. Very often simple shelving, hooks and hangers are used because of installation simplicity. Pegboard wall coverings offer real storage value, and open shelving has serious limitations. The disadvantage of open shelving is that shelves unattached to wall hangers are easily unbalanced and subject to tipping when heavy tools are stored on them. Open shelving units are useless for storing items that you want dust free; items should be sealed away in boxes when dust-free storage is required. And if there are several boxes on a shelf, detailed labeling is required; otherwise, it's difficult to locate items. Perhaps it's best to think of shelving as a bag of candy: It's OK to have one or two pieces (a few shelves), but don't have a diet of it (not everywhere in your woodshop).

Ideally, woodshop storage should be based upon cabinets and/or pegboard. Within these two storage types are worlds of possibilities. Further-more, pegboard offers simple storage solutions and cabinets offer creative storage possibilities.

Building European-Style Cabinets

European frameless cabinet design has definite benefits. The design is somewhat simplified because there is no framework attached to the front of the cabinet. That is, doors are attached to the cabinet sides and not the frame which encircles the front of standard face-frame cabinets. The lack of a frame means better access to the entire inside area of a cabinet — there are no hidden spots as there are behind face-frame constructions. And, while it is true that there are improvements in face-frame hinges, the heart of the European-style cabinet is sophisticated hinges. They come in models that have adjustable tension settings that open to different degrees and that will softly close with a touch. Finally, European-style cabinets require no hardwood — since there is no face frame — and they are usually made from particleboard with a veneer tape on the edges.

CHOOSING MATERIALS

Georgia-Pacific is one of the larger manufacturers of man-made materials, and they broadly classify the common materials into “engineered board and structural panels.” Parti-cleboard, medium-density fiberboard (MDF) and hardboard are termed engineered board, and plywood and oriented-strand board (OSB) are structural panels. Structural panels are used primarily for house construction. Quality grades of particle-board, MDF and hardboard make ideal cabinet

materials if they are used properly. They are readily available, cost less than solid wood or plywood and have dimensional stability, flatness and no voids.

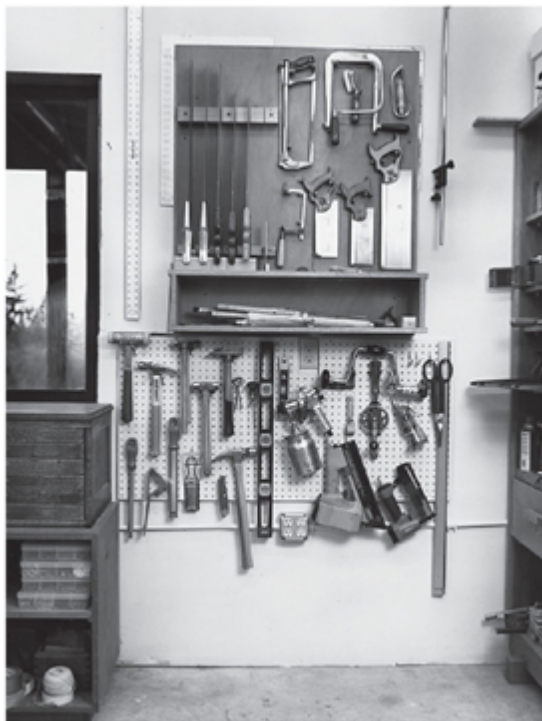
EVALUATING MAN-MADE MATERIALS The disadvantages of particleboard must also be considered. First, particleboard is made with urea-formaldehyde glue, and there are health concerns regarding formaldehyde. To minimize the vapors escaping from particle-board, all particle surfaces and edges should be sealed.

Particleboard can be purchased with a coated surface, or a variety of materials can be glued onto it. Surface materials are usually plastic laminates, melamine or wood veneer. Plastic laminates and melamine are smooth surface materials, available in different colors. Laminates include brand-name materials such as Formica and Wilsonart, and they are generally more expensive than melamine. However, even novice woodworkers can glue laminates to particleboard; melamine is bonded to the surface at the factory. Melamine is the most common and affordable surface material; it is a tough plastic-type material that seals the particleboard or MDF and resists wear, chemicals and stains.

Almost any wood is available as wood veneer. Businesses that specialize in veneers generally stock rare-wood veneers, such as Brazilian Rosewood, or more common woods such as walnut and oak. These veneers are available in sheets and rolls, and they are often sequentially numbered, like pages in a book. This permits matching of grain and color patterns for striking finished appearances. Wood veneer is attached to particleboard or MDF with wood veneer glue, or it's available as factory-attached surfaces.



Here, a tall cabinet holds accessories near the workbench. The cabinet features an angled shelf for easy access to hand planes.



Pegboard storage.

Other disadvantages of particle-board are that it doesn't hold screws well, it's not moisture resistant and its edges are subject to crumbling if roughly handled. Coated particleboard must be cut with good equipment. Commercial cabinet shops use very large-surface table saws with sliding tables. These saws often have two saw blades, a scoring blade and a sawing blade, that then produce a chip-free cut. Smaller, contractor-type table saws might be too small to handle the size and weight of a full sheet of particleboard or MDF. Remember that MDF is heavier than particleboard.



Open cabinet for frequently used power tools.

If your table saw is large enough to handle particleboard sheets, you should use a high-quality tungstencarbide saw blade designed for manmade materials. The generally recommended saw blade has a triplechip grind; that is, every other tooth has three cutting edges. I use a Forrest Manufacturing Company saw blade that produces chip-free, clean, sharp edges in melamine-coated particleboard and it isn't the typical triple-chip design. This blade has a high alternate top-bevel profile (model Duraline HI A/T). The average alternative top-bevel saw blades have 15° to 25° angles, the Forrest blade has a positive rake with a 40° angle so that, as the blade spins down into the bottom melamine surface, it cleanly pierces the material and makes a clean exit cut.

EVALUATING OTHER MATERIALS Although the list of disadvantages of particleboard may seem overwhelming, a similar list can be made for solid wood. Durability, toxicity, weight, cutting ability, finishes, cost and availability are all applicable concerns related to solid wood. The relevant issue is to know the advantages and disadvantages before working with any material.

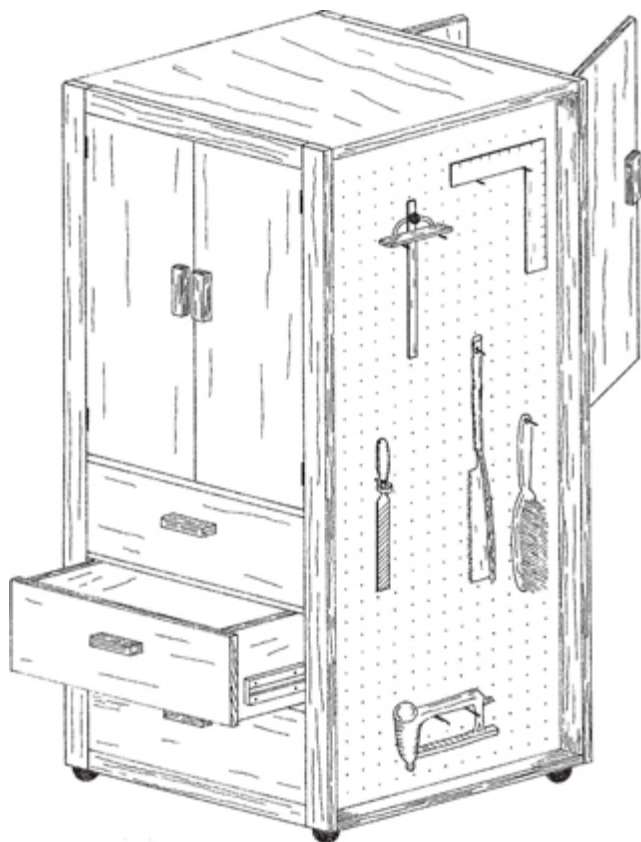
USING PEGBOARD

If cabinets aren't the type of storage that works best in your woodshop, consider

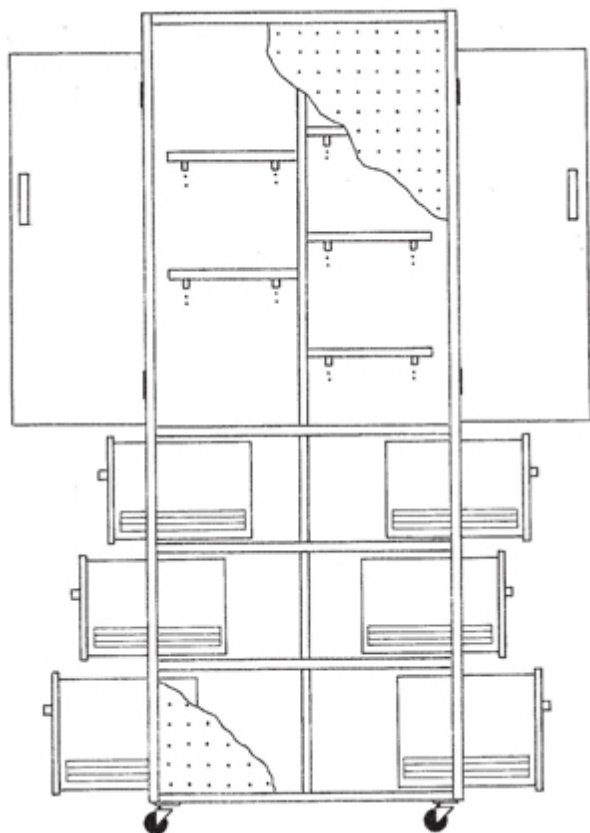
covering all wall areas with pegboard. Use tempered hardboard pegboard because it's more durable than the nontempered type. It holds up well under repeated attachment of the metal hangers. Attach $\frac{3}{4}$ " by 2" by necessary length strips to the wall, attach the pegboard to the strips and then paint the pegboard with a light, nonreflective paint. As you work in a particular area, you will begin to hang tools and accessories relevant to the nearest machine or work area. Pegboard, unlike cabinets and custom storage units, allows for easy woodshop rearrangement. Simply remove all tools, accessories and hangers and reposition them in new areas. Additionally, if you move away and remove everything but the pegboard from the woodshop, the new owner will have a presentable room covered entirely with an attractive wall covering.

Pegboard Storage Tower

A useful storage option for smaller woodshops is a movable storage tower, which looks like a gadgetloaded telephone booth on wheels. The sides can be constructed of solid sheeting, pegboard, recessed shelves or drawers. This unit can be rolled to work areas and then stored in a less used area when it's not needed. Because it's a tower, don't store heavy objects in the upper half — keep weighty objects near the base so that it doesn't tip over. Locking wheels are optional, but are worth considering. If the tower is to be left in one place for a prolonged period, it would be safer to lock the wheels.



Here is a modular storage station, which includes pegboard side panels.



This is a side view of the modular storage station. Shown are opened doors and adjustable shelves.
As shown, the station has six drawers.



Here is a storage tower with a large assortment of tools and supplies. It includes drawers, pegboard, magnetic holders, bins and shelves. Earl Bartell has a small woodshop so the storage tower is kept in a central location.

USING “WASTED” SPACE

Many stationary machines, including the table saw, jointer, planer and band saw, sit on dead space; that is, their stands are open-structured tables or sheet-metal boxes that are mostly empty. I suggest that it's a better use of woodshop space if the metal-legged stands are replaced with shop-made storage units. An under-machine cabinet can accommodate general storage, or it can serve as specialized storage for a particular machine. Any design, simple or complex, can be adapted so that an enclosed table-like cabinet with drawers and doors is both safe and functional. Lockable wheels are optional, although it's often very useful to be able to move a machine for either unusual applications or storage.



Tom Dailey built storage drawers in the heavy-duty frame supporting a metal lathe.

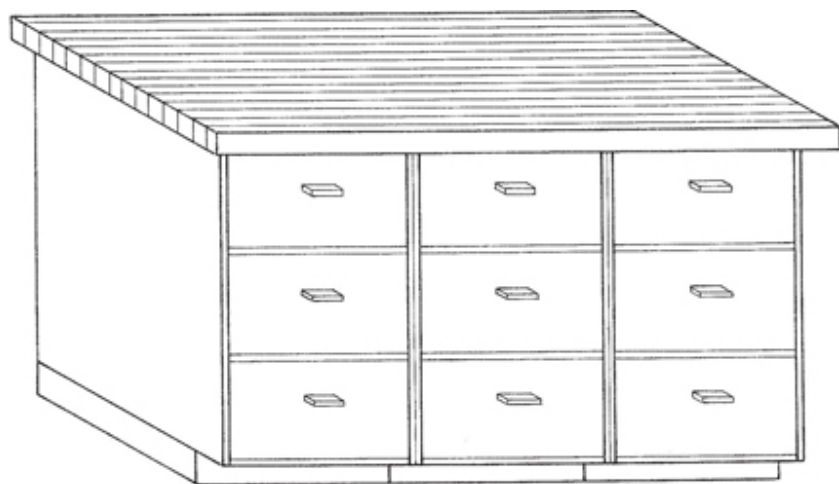
Movable Storage Modules

Large wall-storage cabinets are cumbersome to make and they usually don't relocate well to new locations — within the woodshop or in new location woodshops. Making smaller storage modules has many advantages: They are easier to make and use, and they are much easier to relocate within the woodshop.



Jon Magill has a mobile base under his table saw. Magill also installed drawer storage for his frequently used table saw and his router table accessories.

Roll-around modules with locking wheels make ideal companions to workbenches and stationary machines. A variation of these rolling modules are sets of movable (but no wheels) storage modules — each having the same shape, height, width and depth. They can be set on different-height bases or stacked on each other. Build these units to be the same height as your workbench, table saw or other surfaces so that there is same-height support of oversized materials. The width and depth should be selected to fit your woodshop configuration. Using 18" as an example width, setting a series of 18"-wide storage units side by side produces 3'- and 6'-wide structures. A simple top can be set on the structure, making a very usable work surface. Or another set of units can be set on top of the lower set producing a wall of storage. I recommend that all storage units be attached to walls once they are positioned. Use long drywall screws with fender washers through the storage unit's back and into wall studs. The bonus of this design is that it's possible to reconfigure storage areas as necessary. Adding new units, repositioning units or taking them with you if you move are all easily accomplished.



Three modules with a laminated workbench top.

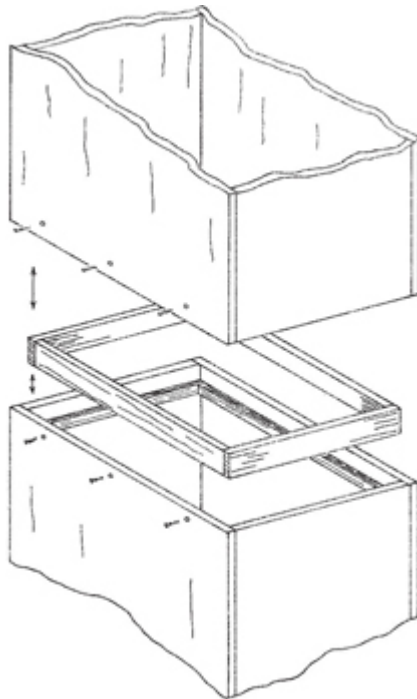




The basic module is shown below. This unit is approximately bench height and consists of three drawers. The drawing on the left consists of six basic modules — all the same size.

LUMBER STORAGE

Lumber storage is the opposite of tool storage. Tools are used and then returned to storage; lumber is in a constant cycle of replenishment, storage and use. Lumber only returns to storage as smaller pieces.



When stacking, secure the modules together using a retaining ring and screws.

Furthermore, lumber sizes and quantities are also in flux depending on the

projects at hand. There's particleboard and plywood for cabinet constructions, solid wood for furniture, and random sizes for carvings and lathe turnings. Wood also is brought into the woodshop simply because woodworkers enjoy wood. Many times I have stumbled on beautiful pieces of wood that I just could-n't resist, or I've gotten telephone calls concerning the sale of someone's private stock of wood. Inevitably, these various quantities of lumber need storage areas in my woodshop. And, the constant question is "How much permanent storage should be devoted to lumber that will soon be made into furniture?" Since lumber is transitory, storage should be designed with simplicity, easy access and accommodation of unusual types and sizes of lumber in mind.

Wall-Hung Rack

For safety and durability, make wall hangers a suitable thickness. If the total weight of stored lumber is slight (moulding strips, long dowels and thin slats), 2"-thick hangers are adequate. If you plan on storing heavier loads, use 4×4 s for the hangers. Use sections of $1" \times 16"$ heavy metal pipe for the supports. Drill the support holes through the 4×4 at a slight angle (approximately 4°). Attach the hangers to wall studs with lag bolts and washers. Attach as many hangers as seem reasonable for the load (wall studs are every 16").

Storage Rack

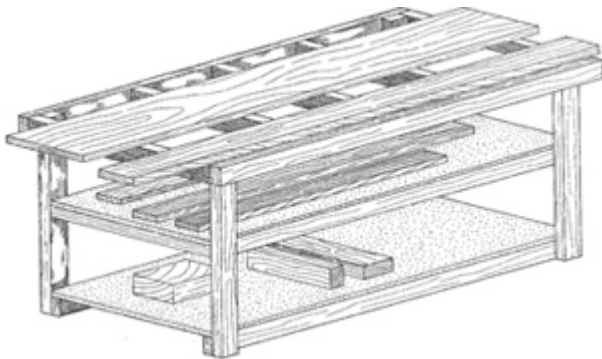
The ideal lumber storage rack should allow access to all four sides. By being able to walk around a storage rack, you can find and easily remove lumber without having to move an entire stack to get to a board in the back. It's a tiring, time-consuming process to constantly sort through lumber to find the right wood for a project, and boards at the back or bottom of a stack are often overlooked. If you can see the lumber from all sides of the rack, removing it will be simpler. Realistically, most woodshops do not have the space for a walk-around rack; lumber is stored against a wall. If space is limited, build a lumber rack with access at its narrower end. That way long boards can be slid in and out with minimum effort.

Make your lumber racks according to the amount of lumber you usually store. It doesn't make sense to build an automobile-size structure if you only store 100 board feet of lumber. However, if you have stacks of lumber to store, build a rack. The frame-work can be made of 2×4 s with $\frac{1}{2}$ "-thick particleboard shelves. The rack's size depends upon room size and the length of stored lumber. For a small-size woodshop consider a 4'-wide by 10'-long rack. Don't make the rack too tall because it's unsafe to store heavy lumber at elevation, and besides, it's difficult to look at lumber that's above shoulder height.

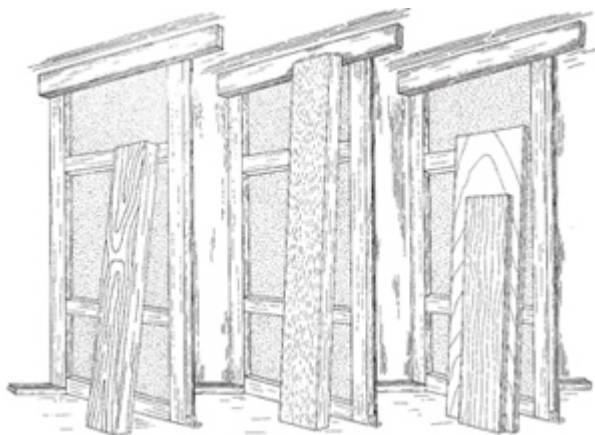
VERTICAL STORAGE RACKS Another version of lumber storage is a series of vertical stalls. The framework is attached to the floor, ceiling joists and wall studs. The stalls can be any reasonably sized openings so that wood and man-made materials are stored on their ends and are easily accessed.



Here you can see the storage of long, thin wood strips and the miter saw work area in Caswell's shop.



Here is a lumber storage rack. The frame is made of 2×4s and particleboard. It can be made in almost any size. Don't make it so tall that it becomes top-heavy and dangerous.



Here are three wood storage “walls” mounted perpendicular to the woodshop wall. Secure these to the wall studs and ceiling joints and anchor them to the floor with steel angle pieces.

Storing Sheet Materials

First, a warning regarding sheet materials such as plywood, particleboard, MDF, hardboard or any other material that is 4' × 8' in size. If your woodshop is small, if your table saw has a small surface area, or if you feel that the material is difficult to handle, don't attempt to cut the full-size sheet on the table saw. Instead, place the sheet on the workbench or saw horses and cut the sheet to a more manageable size using a circular saw or jigsaw.

If you have a lumber rack, a simple storage solution for sheet materials is to move the rack 6" to 12" from the wall and then use this “back pocket” for the sheets. Secure a strip of plywood to the floor to facilitate sliding the sheets in and out. Sheet materials would then rest against the wall and be contained against the side of the lumber rack.



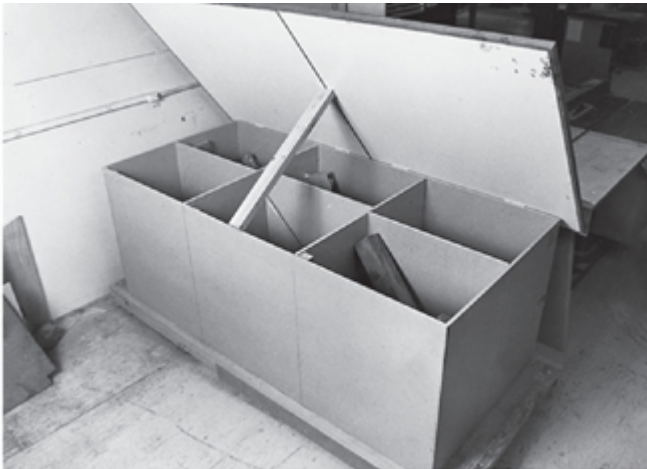
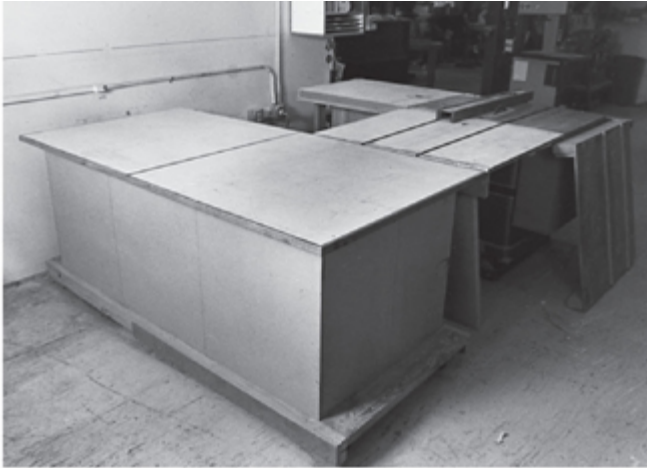
This recycled fish market crate is used for storing turning blanks.

Storing Scrap Wood

Actually, scrap isn't the correct word. Odds and ends might be a better term. These seemingly useless left-overs are actually a valuable resource. After setting aside the odds and ends, the little that's left is waste, the stuff to throw out or burn. Odds and ends are useful for:

- testing machine setup
- determining the looks of various finishing products
- cutting dowel-type plugs to contrast with or complement project wood
- repair work, matching grain and color for antique restoration
- making drawer and door pulls
- making wedges for tenons
- small-size scroll saw pieces
- small-size carvings
- small spindle turnings
- toy constructions
- game pieces

- tool or knife handles
- pieces for woodshop jigs and fixtures



The auxiliary support table for this table saw is also used for storing small pieces of wood, as seen in these two photos.

Storing odds and ends, cutoff pieces and other irregular-size pieces is perhaps one of the most difficult storage problems in the woodshop. The typical solution is being over-whelmed and then storing the odds and ends haphazardly in bins and boxes. That means that every time a small piece of wood is needed, the entire box has to be emptied. Since there is no rational order regarding the size and shape of smaller pieces, it is difficult to sort and store them by that method. My generalized storage of smaller pieces is by length, color and, depending upon quantity, type of wood. In the end, I have shelves and shallow bins with

groupings of dark and light woods, or groupings of walnut, cherry, oak and maple lengths.

For storing very small pieces (2" to 8" in length), I use clear plastic storage boxes — the kind available in most home centers. Currently, I have about 12 of these and I keep them no more than half full.

One clever storage system uses various-diameter cardboard tubes to store longer pieces. Tubes are generally available in 3" to 12" diameters. Cut plywood (or particleboard) disks to fit one tube end and nail in place. The tubes are then placed horizontally on shelves, and pieces easily slide into them. Large-diameter tubes can be found at better hardware stores or at concrete supply houses. These tubes are used as molds for pouring concrete foundations (they are sometimes referred to as sonotubes). Tubes are generally available in 6' lengths and can easily be sawn into 2' or 3' sections.



Here is a typical cubbyhole storage of small pieces of wood usually found in a carver's woodshop.

chapter *eleven*

The Workbench

THE WORKBENCH IS A TOOL. IT'S OK to make it attractive, but also make it useful — and don't be nervous about nicks.

THE UNIVERSAL TOOL

The workbench is the universal tool found in any type of woodshop. It's difficult to imagine any type of woodwork being done without some sort of elevated flat work area. Even if we divide woodworking into power tool users and non-power tool users, there is still agreement that the workbench is a necessity. However, the type of workbench used is very much open to discussion. After all, workbenches have been used for thousands of years which makes for more than a few workbench designs to consider. The workbench may be nothing more than a bench top supported against a garage wall, or it may be a reproduction of a classic Shaker workbench. Quite possibly because of the historical nature of woodworking, the workbench is one of those tools that is evaluated or designed with a reference to the concept of traditional. Because of the popularity of, and the availability of information concerning woodworking, almost every historical workbench has been built; that is, ancient Roman, Japanese, Chinese, medieval English, French, German and Early American, to name a few.

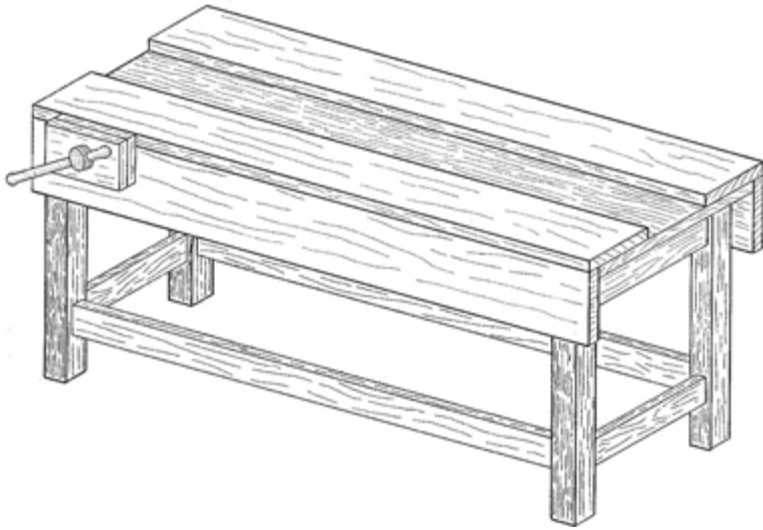
Having said that the supply of information is rather extensive, I would like to focus on the workbench that might function best in today's woodshop. In some ways, the traditional workbench, complete with maple top, front and shoulder vises, is an anachronism — a throwback to another time and place. Perhaps workbenches are analogous to automobiles. The traditional workbench is like an antique classic car — a thing of beauty, a showcase item fussed over by a meticulous owner. By comparison, the workbench made with MDF and designed for use with routers and table saws is like a new pickup truck — a utilitarian object made for heavy use.



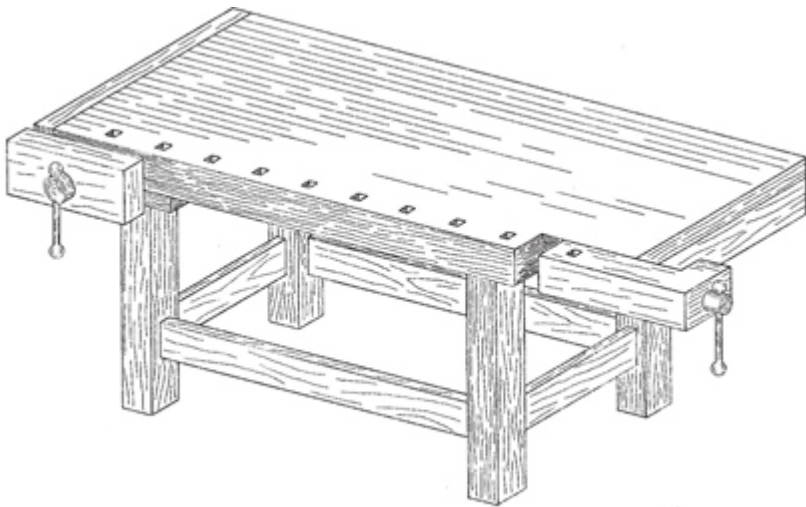
Close-up of antique workbench in Tom Dailey's woodshop.



This is a modern version of the old-fashioned tool chest. Approximate measurements: 16" \times 24" \times 36".



Here is an old-style carpenter's workbench that features a front vise and a top surface with two levels. The center section can hold tools and small objects.



This is a traditionally designed workbench with wooden vises, square bench-dog holes and an open understructure.

What confuses the issue of workbench design is the very enrichment that makes the workbench desirable. Just what is the ideal workbench, or does such a thing actually exist? Are we blessed or cursed by the historical workbench? Does the modern woodworker actually have access to modern workbench theories and designs? Are the advocates of traditional woodworking ignoring the obvious, and

are the power tool users missing the beauty and function of a traditional workbench?

Bench Basics

The stereotypical workbench is about 3' wide and 6' long and has side- and front-mounted vises and a reasonably flat work surface. This workbench probably has some sort of storage either below the bench top or in a tool tray or rack behind the top's back edge. The stereotype workbench is well made and has a thick hardwood laminated top, stout legs and is very heavy. Some workbenches are so heavy that it takes four people to lift and move them. If this workbench is traditionally designed, it has a row of holes accompanying the end vise. These holes are there to secure bench stops (short pieces of wood or steel) so that a board can be held fast between the vise and the bench stops. Generally, this type of workbench was designed and built for use with hand tools, principally bench planes, hand saws and chisels. The other major physical feature is bench height. This is a function of the relationship between the woodworker's height and the height of a board to be worked, both on the surface and on the edge. If a bench is either too high or too low, the woodworker can't maximize body comfort and strength, and the work process will be compromised. If the bench is too lightweight, the planing action will cause the bench to rack diagonally or skip around the floor.

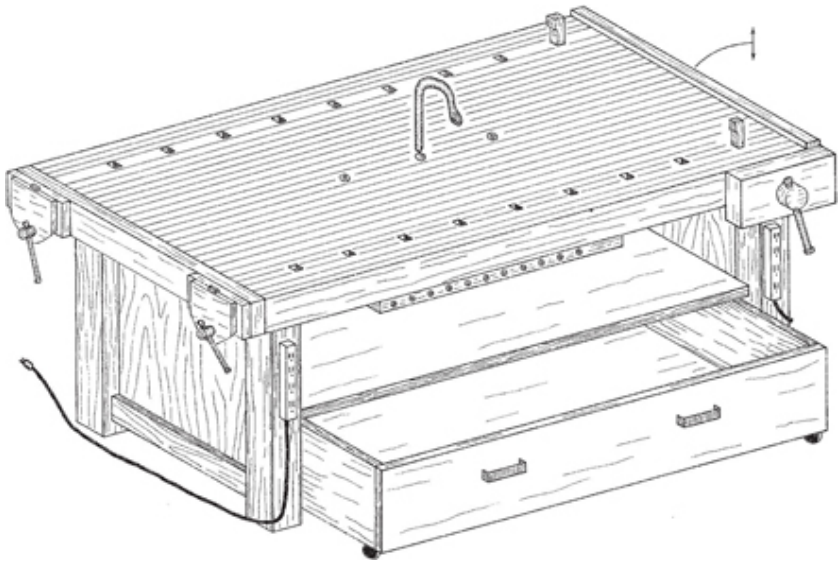
If one studies the workbenches of the time just before the proliferation of electric tools in the United States, it's very noticeable that workbenches were rather utilitarian looking. They had large surfaces, a tail vise and front vise and some sort of device for supporting long boards. Many of the benches appear to be constructed of thick, wide boards with an open-leg housing. Of course, there were exceptions to the open leg design, and there were benches with storage areas. However, tools were generally stored in tool chests kept near the workbench.

Few of us now store tools in large tool chests that look like steamer trunks. Today's woodworker prefers to build large wall cabinets, or multiple wall cabinets, for storage. We now design workbenches so that there is some storage under the bench top. Having smaller woodshops does require the full utilization of all spaces; the additional bench structure and weight of the stored tools helps to make a strong and heavy workbench, thus reducing vibrations and bench movement when it's used.

DESIGNING A WORKBENCH

The real question about workbench design is: How will the workbench be used? Nostalgia aside, that revered turn-of-the century workbench was used for long hours of work and commerce. Someone stood at that bench for many hours a day and made things with hand tools. That tool chest was filled with assorted hand planes, moulding planes, braces, auger bits and so forth. These chests were frequently so filled with tools that one description of them might be crammed orderliness. Often, hundreds of tools were nestled within a maze of special boxes,

drawers, containers and holders. Also, the lumber used was large and heavy, and rough boards were often hand planed and hand sawed. This was state-of-the art equipment, as well as the work style for that time. Is that how the modern woodworker now works? If so, then there are many historical texts available that will help to recreate that type of workbench. If, however, you are using electric tools and working with plywood, perhaps a different workbench design is in order.



This concept workbench features two rows of bench-stop holes, two end vises, one front vise, a storage shelf, a rollout storage container, electrical boxes on its front legs, an adjustable edge stop, a hinged support leg and a bench hook in the center of the worktop.

This isn't about not using hand tools or bashing traditional tools. Instead, it's important to design the workbench so that its function matches today's needs. Although it's very possible to own and drive an antique car, it doesn't make sense to use that car for stop-and-go rush-hour driving. The same applies for the workbench. If we use the traditional workbench for modern work, perhaps we are creating an unnecessary struggle. Generally, hand tools are now the secondary processing tools and are mostly used for detail work, such as trimming, cutting joints or planing an edge. The primary processing tools are the table saw, compound miter saw, radial arm saw, band saw, jointer and planer. Furthermore, the principal tools that aid in refining boards into objects are routers, drills, sanders, scroll saws and biscuit joiners. And the old fellows of the past didn't have plywood, particleboard, MDF and other 4×8 sheet goods to work. Plywood and other related man-made materials, besides being heavy and awkward to move, aren't made to be cut, shaped or prepared with hand tools.

The issue is that we now use an assortment of hand and power tools and materials requiring workbench performance far different than that of 1849 or

1905. If you're building a workbench for the first time, this might be the time to reassess the typical workbench design and build one from a fresh perspective.

Design Considerations

- workbench height
- material used for bench top
- surface area required for accommodating materials
- size and shape of workbench relative to the type of work and tools
- movable or not
- freestanding or against wall
- holding system(s) for routing, drilling, belt sanding, finish sanding, carving, hand tool use (planes and saws)
- use of clamps on the workbench
- tool storage
- electrical hookup
- vises: front, side, specialty
- make single, special or multipurpose benches

Workbench Height

Bench height is one of the most important dimensional features to consider. The proper height will allow the user to work comfortably and to efficiently use tools. Improper bench height leads to stooping over, sore back and neck muscles and awkward arm movements. I once was instructing a class on using hand planes and a student showed me a board edge that he had just finished. I sighted down the 5'-long board and was very impressed. There wasn't one place on the edge that was square to the board's surface. In fact, the board was reminiscent of a Mobius strip. Not wanting to hurt his feelings, I asked him to demonstrate his planing technique to me. What became obvious was that the work surface was too high and the strange edge was a result of his unnatural reach to the board and the change of his body position as he moved down the board's edge.

There are several popular heights for general-purpose workbenches. Most commercially made workbenches are 33" to 36" in height. Of course, it would be impossible for manufacturers to offer an infinite variety of bench heights. Therefore, if you want this type of workbench, it would be best to purchase either the correct height bench or one slightly lower. It's much easier to place blocks under the legs to raise the bench than it is to cut the legs and make the bench

shorter. I'm 6' 1" and my workbench is 35" in height. I'm not sure that's an ideal height for others, but for me it's comfortable.

To determine the height for a workbench, you must first determine the height from the floor to the top of the work you are doing. For example, a 1" by 10"-wide board is to be edge planed. If the board is clamped in a position so that the edge is up, the edge height is then approximately 43" from the floor. This was computed by assuming a 35"-high workbench, and the board has 2" of width in a front vise. If that same board needs surface work, the floor-to-work surface height is 36". If you are comfortable working within the 36" to 43" range, 35" is a good bench height.

First, prioritize the tools that you will use most at the workbench. Make a list of the tools that you will use, from most to least. For a hypothetical example, the most-used to least-used workbench tools might be a router, belt sander, chisels, hand planes and hand saws. Now, make a best guess as to the height above the bench top that these tools would be used. Generally, the router, belt sander and chisels will be used on flat stock ($\frac{1}{4}$ " to 4" in height), and hand planes will be used mostly on edges ($\frac{1}{4}$ " to 24" in height). You may want to make mock-ups of various heights and pantomime the motions involved in using belt sanders, routers and hand planes.

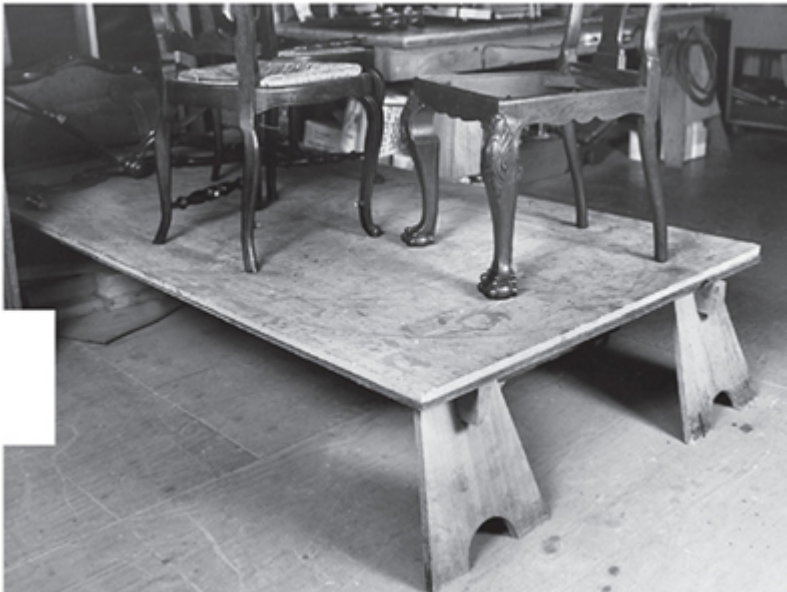
Since there is no perfect height, pick a height that seems to average out the various work heights from this pantomime effort. Have someone else watch you doing the pantomime to find out if you unconsciously stoop over while working. Surprisingly, this is common, and you may find that at certain heights you keep a straight back and are also comfortable in this position. You might find that the generic 33" to 36" heights are fine, or you may find that 30" or 38" is more comfortable for your needs. Woodworkers don't come in one size, and there is no reason to assume that workbenches should either.





This low, mobile workstation features drawers on both sides of the unit and wheels. Lockable wheels are recommended. The unit is approximately 16" to 24" in height.

There is one other situation in which bench height is critical. There are a number of jigs and fixtures that are useful for specialized work, including such things as the Leigh Dovetail Jig or a shop-made tenoning jig. If the jig is clamped to the workbench, the workpieces must be shorter than the distance to the floor. There are two solutions: Dig a hole in the floor for the longer boards, or raise the jig above the workbench. Since the hole option isn't reasonable, many woodworkers have built higher benches for this function. Do not operate a router at a raised bench in a way that your face is in-line with the cutting action: This is very dangerous. Nor should you use a movable step stool or ladder to reach the jig. The best method is to build a box that's 3" to 10" in height, attach the jig to it and then clamp the entire assembly to the workbench.



Low workstations are perfect for work projects that are too tall for a standard workbench.

If I had the space, I would have two workbenches. One bench would be at a standard height and would be used for joinery, clamping and general purpose use. The other bench would be approximately 18" to 28" in height, and it would be used for placing chairs, chests and other furniture pieces on for assembly, detail work and finishing. When detailing or finishing a piece that is either sitting on the floor or up on the standard bench, it always seems to have a wrong visual perspective, or the piece is in an awkward, hard to reach position. A lower bench makes it easier to see and move the piece.

Benchtop Materials

Is a laminated maple bench top better than one of 2 × 4s and MDF? The maple top certainly looks better, but does it add to the functionality of the bench?

Traditional workbenches are usually made of hardwoods such as maple, beech, or oak, but these benches were developed when natural wood was the only material choice. Much can be said about the natural beauty of wood benches, a beauty enhanced by the patina of age and use. When you are making fine woodworking pieces, it seems almost natural to visually connect a beautiful bench with the workpiece. There is the old adage that you should use your best tools when attempting your best work. Perhaps the luster and charm of a seasoned hardwood bench do help motivate a woodworker toward a higher level of work. A hardwood bench that has dovetail and mortise-and-tenon joints is a constant reminder of the best of woodworking and craftsmanship. The hardwood bench top does have features beyond beauty. A 2"- or 3"-thick benchtop is ideal for work that requires the pounding of a mallet or hammer. The top's thickness and density offer a solidity that minimizes tool recoil, bounce-back and workpiece stability. The sheer weight of a solid-wood bench top also provides stability and stiffness which means that heavy materials and projects won't distort the top. Hardwood tops are easy to maintain; as the top wears or even distorts, it can be reflattened with hand planes or belt sanders.

But there are other considerations regarding laminated workbench tops. The principal drawbacks to a laminated top are that they are expensive, difficult to make and heavy to move. There is approximately 54 board feet of wood in a 3" × 36" × 72" benchtop. Add on an additional 20% for waste and that's about 65 board feet to purchase. Call a local lumber-yard and get a quote for the current price of maple, cherry and oak.

When preparing wood for a bench top, each lamination surface must be planed very flat. Then the entire lamination assembly must be carefully aligned when it is glued so that it will remain very flat during and after gluing. Any twists that occur during glue-up will result in a piece requiring difficult work to make it flat. Other factors to consider: A laminated top is heavy and awkward to move, and when it's being glued up, heavy-duty bar clamps spaced about 6" apart on either side of the workpiece are also required. Someone once said that you need a workbench in order to build a workbench. That's very true when dealing with the gluing-up process. A workbench is flat and therefore the ideal surface on which to

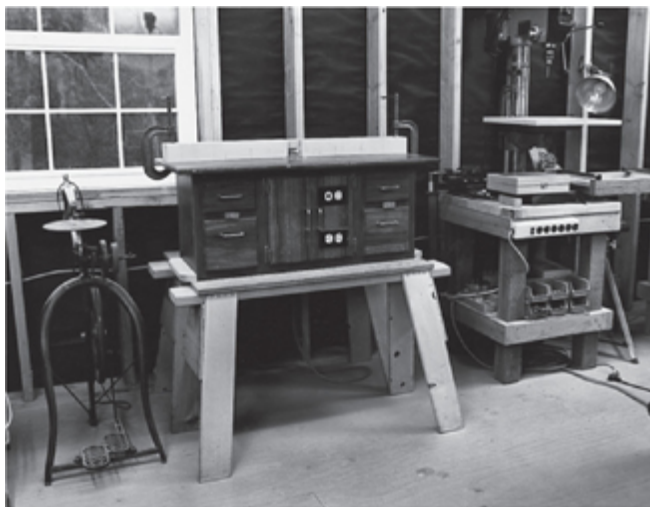
rest the clamped-up workpiece. If you plan on using a garage floor as a resting surface for the glued assembly, can you be certain that the floor is flat? If it isn't, the uneven floor will introduce twists to the clamped workpiece.

I've noticed that many more woodworkers are now building bench tops with man-made materials. Part of the reason for this is that it's easier to construct the top with sheet materials. A frame is built first and then one or more layers are added. Often the top layer is attached with screws so that it can be replaced when it's worn. The principal materials used are MDF, tempered hardboard and particleboard. Solid-wood edges are attached to the top so that the sheet materials are contained and don't break or crumble.

It's much easier to build a 3' × 8' top from these materials than it is to build one of hardwoods. There is enough material in two 4 × 8 sheets to construct a 2¼" × 32" × 96" top (two 32" and two 16" strips). The compromise necessary when using manmade materials is that the top isn't as dense or resilient as hardwoods. However, flatness is easier to attain, and the top can be replaced or repaired easily. I've also noticed that some woodworkers pencil-sketch directly onto particleboard tops. Some actually draw, with T-square and triangles, full-size drawings of their current projects. When that project is completed, the drawings are erased and the surface is ready for the next one.



Doug Matthews likes having a variety of portable workstations for his antique restoration business. This workstation is used much like a typical workbench.



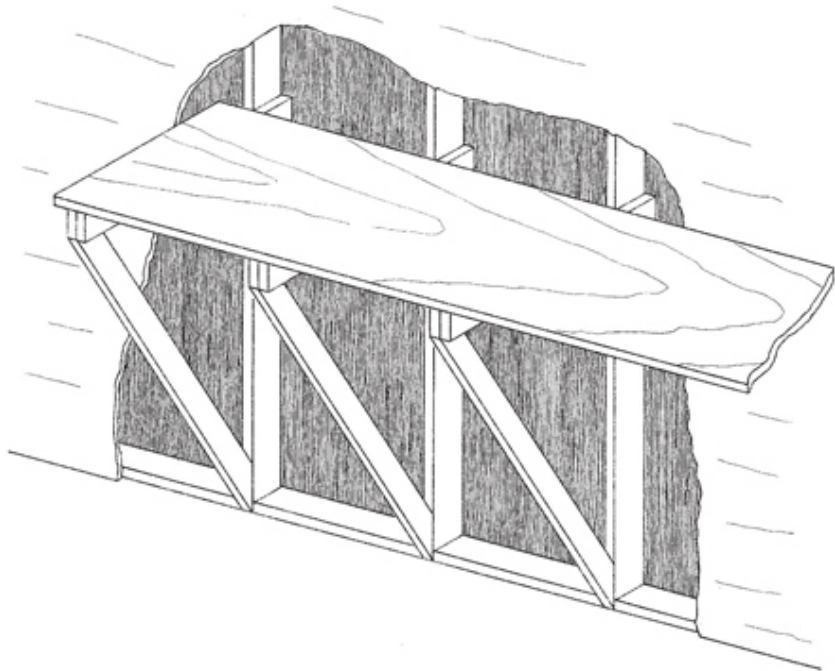
This portable workstation is used to support a router table.

SURFACE AREA REQUIRED FOR MATERIALS It may seem obvious that a workbench holds stuff on the top surface, but when one is working on a project with stacks of wood and there are odds and ends of wood, assorted tools, power cords, glue bottles and so on, the top of the bench gets cluttered rapidly and the bench seems small. I suppose the cliché, whatever size you have will always fill up, applies. So the solution is to build the largest bench possible. A large bench isn't just for building large projects. Actually, the workbench is the only open flat area in a woodshop that isn't flooring or doesn't have a blade projecting out of it. The bench then becomes the focal point and command center for everything from stirring paints to sorting screws. Rarely is my workbench empty. And when I use it for sorting wood for a project or to stack furniture parts, some part of the bench is still filled with assorted tools and notebooks.

When I read books about the Shakers and their woodshops, what I see are beautiful, clean and empty workbenches — and I wonder what those large surface benches looked like when they were being used. I imagine stacks of wood, assorted tools, boxes of hardware and cans of finishes everywhere on that bench. I appreciate that the Shakers placed great value in neatness and cleanliness, but I do believe that during work, those large workbenches were covered with stuff.

Freestanding or Against a Wall

Workbench location is simple: Place it against a wall or let it stand in the woodshop so that you can walk completely around it. If space is at a premium, place the bench against a wall. This reduces some uses, such as placing long boards and clamps across the bench and using all four edges. However, the workbench will be more stable when it's attached to a wall, and the wall above the workbench usually becomes a storage area for commonly used tools.

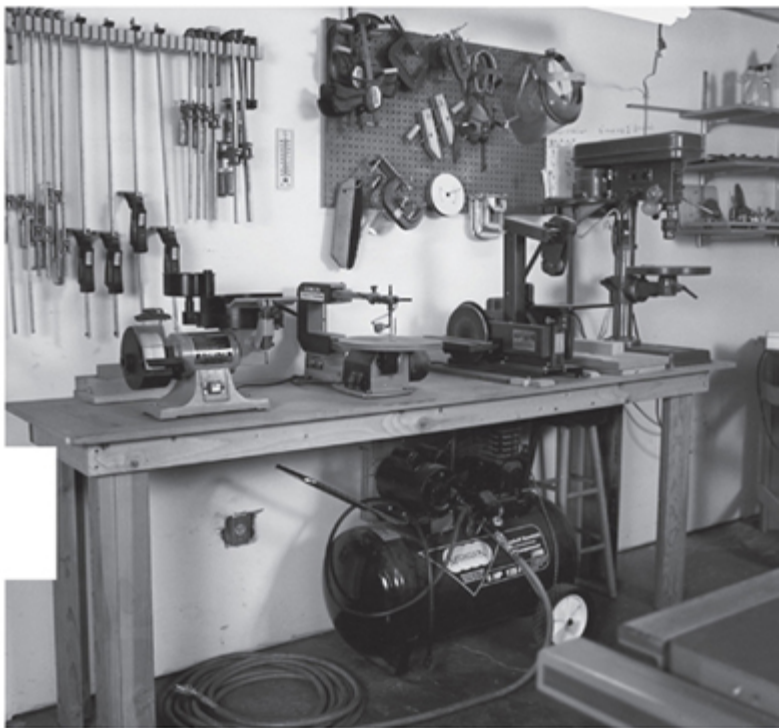


If you need a work surface in a garage and would like to have the floor area unobstructed by table legs, attach diagonal braces to wall studs.

Freestanding workbenches can be left at one location or moved as necessary. I appreciate the freestanding workbench because I can position long bar clamps across the bench when gluing, and because I can work completely around an object on the bench. Not having to move an object is especially useful when repairing antiques or applying finishes. Tool storage is further away with this type of bench, but it's not that much of a distance and generally isn't a problem.

Shape of Workbench

Another stereotype of workbench design is the rectangular bench — 22" × 72", 24" × 78", 30" × 66", etc. Generally, this shape is comfortable for most hand tool work; however, when coupled with the traditional two vises, this shape doesn't always lend itself to power tool use. End vise and bench stops were designed to secure a board when using hand planes and chisels. The vise stop and benchtop stop usually are about $\frac{3}{4}$ " wide, and the board is pinched between the two. When you study most traditional workbenches, it becomes clear that the design emphasis is the bench-stop system, and these benches were designed to secure more or less narrow boards. Traditional workbenches are definitely pre-electric and pre-plywood.



Small benchtop tools are neatly arranged on this functional workstation in Dean Bershaw's woodshop.



Derrick Burke's woodshop is a converted carport with limited space (single-car size). So he attached a space-saving simple workbench to a wall. The bench features a replaceable particle-board surface with round dog holes and a Record vise with stop.



Harry Charowsky's workbench, made from 2" \times 6" fir boards measures 29½"-wide by 114½"-long

by 36 $\frac{3}{4}$ "-high. It features drawer storage, movable workpiece support, shop-made hardware for vises, and it has a shop-made mobility system (underneath the bench) that makes it easy for one person to move the workbench.



Dave Buck has more than enough space in his woodshop for this oversize workbench; 144"-long by 39"-wide by 33 $\frac{3}{4}$ "-high, it weighs approximately 1,500 pounds.

A description of a working-condition scenario is in order to picture limitations. Suppose a 24" square of plywood requires a rabbet on all four edges. If the bench stops are used, the router with fence and bit can only cut one edge at a time, and therefore the board will have to be unclamped and re-clamped three more times because you cannot continuously cut all four edges in one pass. Most likely the router fence won't clear the bench top and the two bench stops are also obstructions. Of course this four-edge rabbet can be cut on the router table, but there are times when the workbench offers easier setup, except for the bench stops. Another common problem with the bench stop and end vise occurs when belt sanding. The nature of a belt sander is that the belt turns so that when it's running, the belt pulls the workpiece toward its back end and the operator. Since the workpiece is pulled in one direction, it's a common practice to place the workpiece against a bench stop and sand. This works reasonably well, except when the workpiece is wider than a few inches. When the belt sander is aligned to the bench stop, it pulls squarely against the stop. If the sander is at one side or the other of the board, it will cause the board to pivot against the stop, making sanding nearly impossible. The traditional solution to this is to use both bench stops to secure the workpiece. If, however, there are numerous workpieces of assorted lengths, the operator will constantly be moving bench stops to different bench holes and tightening, loosening and retightening the vise. This makes for slow work, especially when using a fast and powerful power tool like the belt sander. Another solution is to clamp a long strip of wood in the end vise so that

the entire width of the workpiece is touching it. This reduces the pivoting motion and makes sanding much easier and quicker, but many of the traditional end vises aren't designed for this type of clamping. And some traditional workbenches that have rear-mounted tool trays also have narrow flat areas, and these two features make it difficult to secure wider workpieces. If the workbench is against a wall, wider workpieces may not have sufficient space for safe and easy work.

Knowing the type of work destined for the workbench is critical to its design. With that information you can configure the workbench accordingly. There are definite work conditions relative to the type of material being used for projects. A stack of plywood pieces could actually tip over a lightweight bench. Or the workbench shape might make it difficult for certain constructions. The general shape of the workbench will affect more than woodshop area square footage. It will affect the ease of positioning work projects, tool use, tool storage and operator maneuvering. I'm not a fan of the traditional Scandinavian bench, which has an L-shaped wing projecting from the edge. Part of this dislike is because I'm left-handed — and the benches I've used aren't. But more importantly, I really don't like that front projection. I realize this traditional design was a cornerstone of hand tool usage and many hand tool advocates still like this design, but for me, it's awkward to use and easy to bump into when walking by the bench. I see no reason to have this type of clamping/holding projection for hand tool use.

Movable or Not?

Smaller woodshops often require machine mobility. More machines are being mounted on mobile bases than ever before. Mobile bases permit the woodworker to move very heavy machines from storage to an area of use and then return the machine to storage. Mobile-base frames have locking wheels so that the machine can be used safely. Generally, workbenches aren't considered mobile objects, but a few years ago, table saws and jointers were thought of only as stationary machines. I would suggest that if a workbench is made mobile, a retractable mechanism should be used for the locked position. This allows the workbench to be moved, but when it's in position the bench legs would be in direct contact with the floor. If the workbench is in some sort of carriage that has locking wheels, the legs aren't directly touching the floor. Aside from mobility, it's necessary to avoid micromovement in the bench once it's in position. If the floor's uneven, shims are easily tapped under the legs. Workbenches that are in carriages will have micro-movements that are annoying and bothersome when you are trying to do fine detail work. Solid contact with the floor is best. One possible solution is to make a hinged wheel system for each leg set that can be flipped up out of the way once the bench is in position.

Movable workstations work well when the woodshop shares space in a garage. Folding sawhorses (hand-made or store-bought) are set in position, the work surface is secured, and tools are then attached to the workstation.

Holding Systems

Is there anything in the woodshop that's a single-function object universal enough to encompass all woodworking needs? Can you do work with only one drill bit size, one chisel or one grit of sandpaper? If you can manage this feat, I'm impressed. The very nature of woodworking is one of increments and subtle adjustments. Rough-sawing a piece is the opposite of fine-tuning. The very nature of a woodshop is the variety of tools and machines that are used between these two extremes.



This is Jon Magill's portable workstation for a horizontal router table and a planer. The commercial sawhorses have a retaining track on their top surface, and they retain cleats that are mounted on the underside of the work surface.

Assuming this point is accurate, why should we assume that a workbench should have only one or two methods of securing workpieces? Does the traditional bench-vise and bench-stop system perform adequate work for cabinetmakers, lathe turners, carvers, antique restorers, picture frame makers and miniaturists? Or should function be the measure of bench design? I know that I've

modified my workbench to accommodate router and belt sander use and the periodic woodcarving that I do. That's the heart of this issue: Define your most performed tasks and develop specialized holding systems for those tasks. Standard-issue holding systems might get you close to the best way of holding something, but efficiency necessitates fine-tuning the holding systems.

The principal purpose of any holding system is to secure the workpiece while work is being done. The holding system should be easy to use; it should grip and tightly hold the workpiece, and it should store away quickly and efficiently. Complicated holding systems consisting of many parts should be viewed with skepticism. Infrequently used parts and accessories are easily lost, abandoned or forgotten.

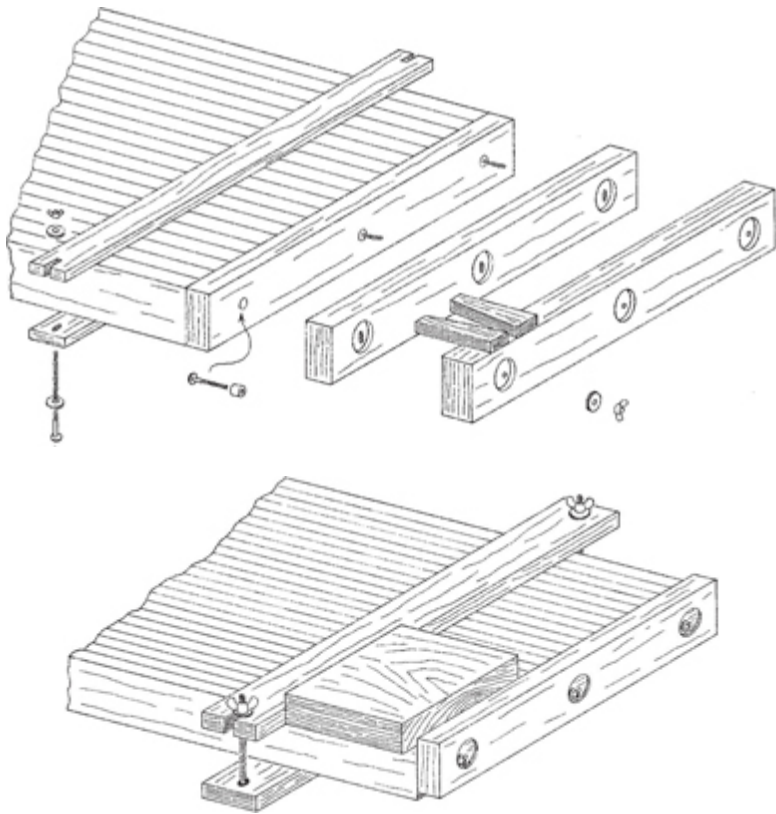
Without overdoing the diversity concept, there are a few basic woodworking functions that require specialized workbench holding systems:

- routing
- drilling
- belt sanding
- finish sanding
- carving
- hand tool use (planes and saws)

Ideally, any workpiece should be secured so that clamps or stops don't interfere with tool use. For example, it's very easy to secure a workpiece to the workbench with a C-clamp, except that it's nearly impossible to continuously use the router because the clamp blocks access. The same problem applies to carving. If the workpiece is secured with C-clamps, the carver has to be careful not to push the chisel into the clamp, or the clamp has to be constantly moved to reveal carving area.

To avoid this problem when routing and sanding, there are two commercial systems: a foam pad, similar to the padding found under wall-to-wall carpeting, and vacuum vises. Vacuum vises offer incredible holding strength, but they require an air pump motor and an air line, and they are expensive. Vacuum vises might be better suited to commercial woodworking because their efficiency is related to all-day usage and time savings. The foam pads are inexpensive, easily used, easily stored away and replaceable.

The end of the workbench is easily modified to hold different types of board stops. These simple devices are useful for capturing workpieces, and work well for belt sanding or relief carving.

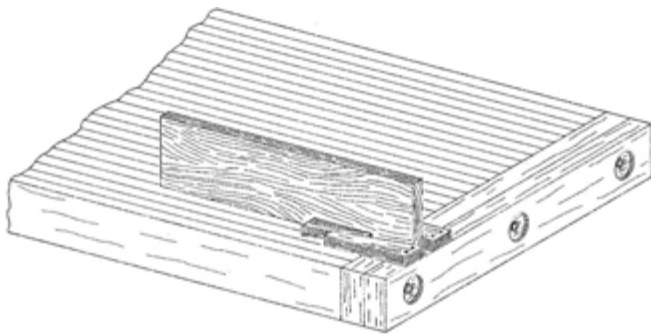


This drawing illustrates how the workpiece is secured with an adjustable edge stop. Also note the use of an additional retainer system: two strips of wood secured with wing nuts. The top strip has cutouts so that the bolt is easy to position.

Different edge pieces that can be attached to the end of the workbench are shown at left. The workbench edge has a cap piece that includes three exposed bolt threads. These bolts are attached through glued dowel sections. The board in the center features three recessed locations with elongated slots.

The bolt threads are through these slots, and the edge board is secured with wing nuts. The edge board can be raised as a catch board at the end of the workbench. This is useful for belt sanding workpieces. The edge board with two attached wedge-shaped pieces at the right side of the drawing is also secured with wing nuts to the three bolt threads. This edge board is useful for securing workpieces when edge planing with hand planes.

Note: There are a number of other edge board designs possible that can be incorporated onto the end of the workbench.



This drawing illustrates how a workpiece is secured with the use of additional wedges.

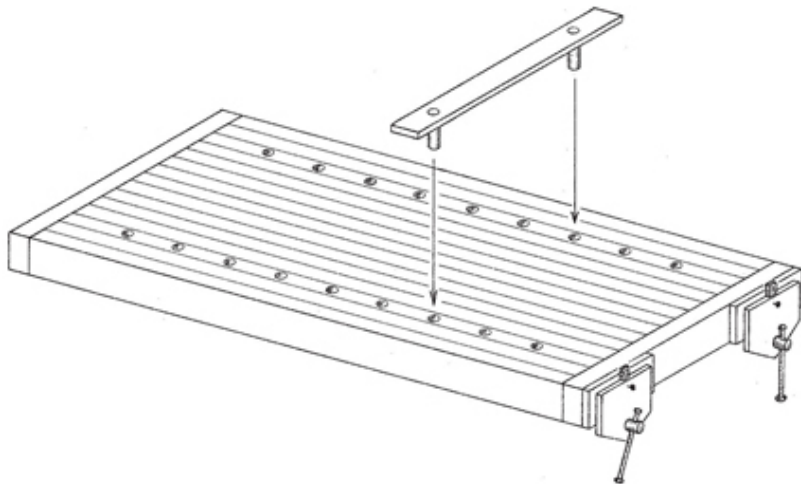
This bench accessory can be further enhanced by the addition of a thin strip located at the other end of the workpiece. This secures the workpiece so that sanding, some routing and other surface work can be done. These strips can be clamped or made to fit bench-dog holes. They also can be shaped to match oddshaped workpieces.

The router is such a useful tool (it's really nothing more than a highspeed motor with handles!) that a separate workbench dedicated to router use is worth constructing. This workbench should be built higher than a standard bench, approximately 40". This height is determined by holding a router with your elbows bent at 90° and measuring the distance from the floor to the bottom of the router. The bench should be somewhat narrow, approximately 12", and 48" to 60" in length. The narrow width permits router access to either side of a workpiece that is off the benchtop. Also, construction projects, such as boxes or drawers without tops or bottoms, can be slid onto the bench top for work. Attach an end vise with a 12" stop and drill rows of holes along both edges. If you drill round bench-stop holes, bolts with square heads make excellent stops. They will pivot when either a straight or curved workpiece is aligned against them. The base must be constructed so that the router bench won't tip over. Heavy pedestals with broad feet are recommended.

Another useful workbench accessory is the sanding platform. Make the platform box approximately 3" to 6" in height and whatever length and width you choose. It is clamped to the workbench, and it has a port for attaching a vacuum hose. The top surface is perforated with either slots or holes so that when the vacuum is used, dust is drawn down into the box.

There is so much diversity in woodcarving that there isn't a single holding system for all applications. For some carvers, a heavy-duty leather glove is adequate. They simply hold a small piece of wood in the gloved hand and carve with the other. Other carvers might be using large die grinders to shape a tree stump. This sort of workpiece is heavy and probably requires minimal clamping. Typically, carvers use some sort of screw or lag bolt mounted point up through the workbench top and secured into the base of the workpiece. Another option is power arms. These have movable head plates that are attached to the base of the

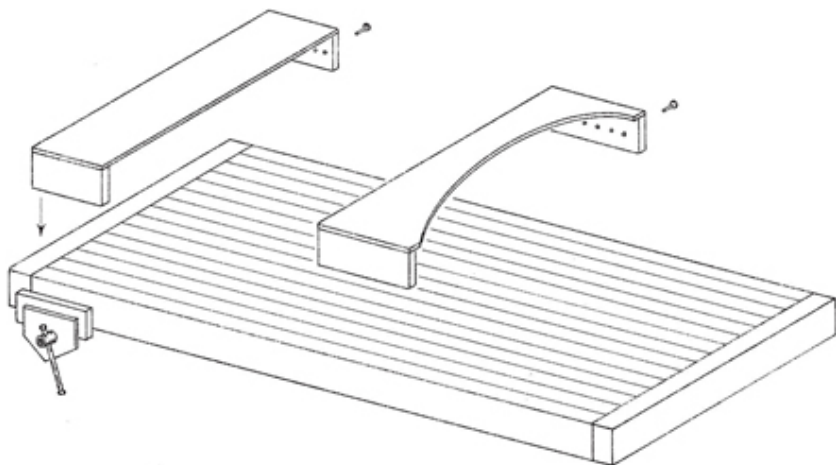
workpiece. By lever action, the head can be moved so that the workpiece can be worked on at an infinite variety of angles. Generally, power arms are not meant for very heavy workpieces.



This benchtop has only a front vise. Stop boards, with both straight and curved edges, can be held in the vise and secured on the opposite edge with screws. These stops are very useful when using the belt sander. The operator stands at the left end of the vise and the workpiece is butted against the stop board. When power sanding, the workpiece is drawn against the stop and secured. If a sander is used from the right side, the board will no longer be secured and an additional stop or clamp is then required.

Clamps on the Workbench

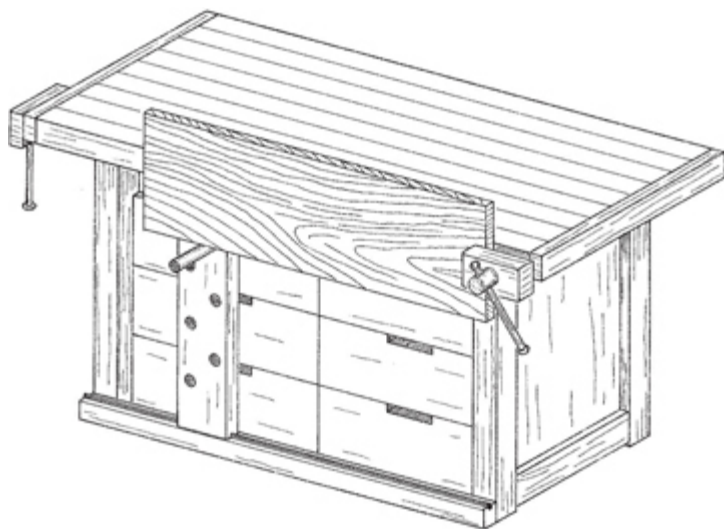
In most woodshops, floor space is a luxury and the workbench serves multiple purposes. The workbench is the flattest work surface in the woodshop, and if it's wide enough, it can be used for clamps when gluing. I use my workbench to support bar clamps up to 4' long for gluing. Since my bench is 7' long, I can glue up substantial workpieces. The I-beam-style bar clamps are shaped to rest on their clamp fittings, making it easy to set them almost anywhere on the benchtop.



Here's a workbench with drawers. A heavy workpiece is held with the vise and movable support. The support has holes at different heights.

Another useful clamping situation is being able to secure workpieces anywhere on the workbench with adjustable, deep-throat clamps. If the workbench has drawers, tool trays and other irregular-shaped constructions under the benchtop, this usually reduces clamping in that area.

I chose to have the benchtop edges free of any obstructions so that I could use clamps on all four edges. This permits me, for example, to clamp a workpiece on the back edge and then continue working at the front edge.



Here's a workbench with drawers. A heavy workpiece is held with the vise and movable support.

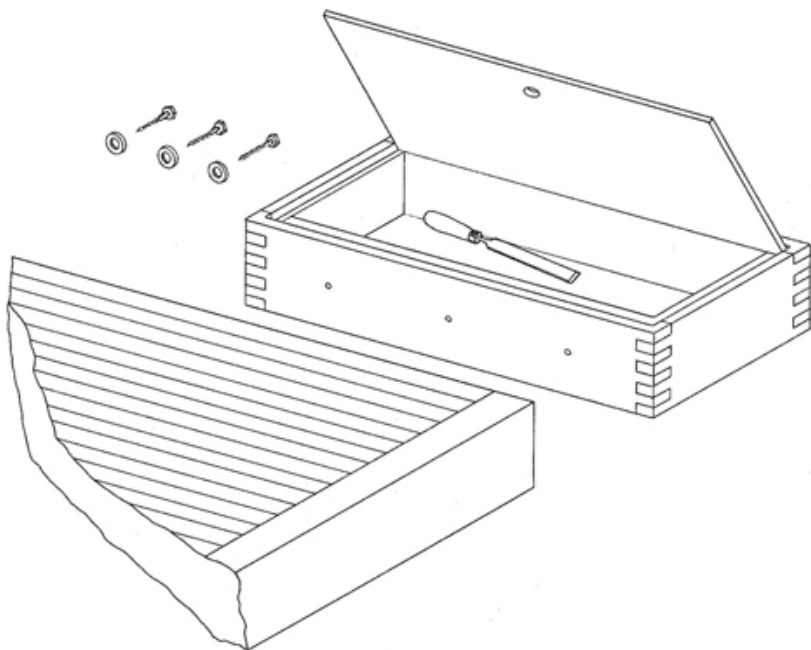
The support has holes at different heights.

Workbench Tool Storage

The ideal tool storage would be that all tools used at the bench are stored within arm's length. Since most woodshops are compact, storage is reasonably close. However, there are tools that are used so frequently that some storage at the workbench is necessary. Once again, prioritize your tools and decide on the most important. The typical storage area is at the wall behind the workbench, the workbench itself and shelves and cabinets somewhere within the shop.

Many workbenches incorporate a tool well or tool tray that is located either on the back edge or the end of the workbench. The world seems to be divided into two groups: lovers and haters of tool trays. I'm not fond of them because they always seem to be filled with debris and hand tools that are hidden under other tools. My biggest gripe is that tool trays minimize workbench clamping area, and they create extra benchtop width but no extra top area for supporting wide workpieces such as chair legs. To overcome these shortcomings, instead of a permanently installed tool tray, make a tray that is movable and has a top lid. The tray can then be secured at any location or can be removed altogether. The lid will help keep unwanted debris at bay and will add additional surface area.

First consider several of the limitations of storage near the workbench. Wall storage behind a bench means that storage is useful only if you can reach it. Tools stored 6' from the floor probably can't be reached if you are standing in front of the bench. Storage underneath a bench top is always subject to being blocked by clamps, workpieces and anything else positioned in front of the bench. The workbench area is space-limited, and there is no need to store tools here that are infrequently used. I store a few power tools on a shelf in the workbench, and the majority of items, such as power tools, measuring tools, chisels and block planes, are two or three steps away in drawers and open cabinets. My personal choice of power tools stored at the workbench is based on frequency of use and the notion that some tools just seem to belong at the workbench. I have a cordless drill, a 4" × 24" belt sander, several finish sanders and a plate joiner all at arm's length. I also store several plastic containers on this shelf. In them, I keep an assortment of nails, small screws and washers. Routers and other power tools are about 6' away, and most of the hand tools are about 4' away. The importance of these distances becomes obvious when work is underway. The closer the tools are to the work project the less frustrating it is. In fact, traveling 6' during some constructions seems like 20'. Someone once said that, given time, anyone can cut dovetails, but to cut good dovetails quickly requires a master craftsman. If the time factor related to finding and selecting tools can be reduced, we take one more step toward better craftsmanship.



This is a small tool tray with a lid. The tray is attached to the edge of the workbench with lag screws. The lid is useful for two purposes: an additional work surface that is flush with the benchtop, and to keep debris out of the tool well.

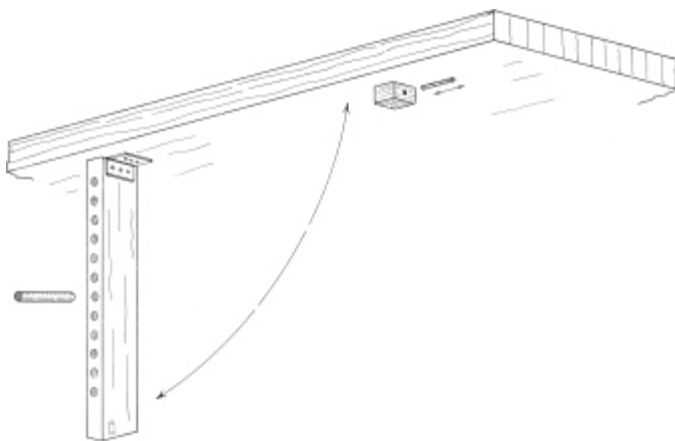
Electrical Hookups

We have entered the 21st century, so feel free to add electrical outlets to the workbench. I suggest electrical strips attached to the legs as the principal outlets for the workbench, with additional wall outlets at either end of the workbench area. Electrical outlets behind the benchtop create the problem of electrical cords running directly over the workbench. This adds to the confusion and clutter which intensifies during project construction. Additionally, it's dangerous to have electrical cords draped over the work area simply because these cords are too easily cut by sharp cutting tools or operating power tools. Electrical cords that dangle freely to the floor are much safer. Electrical outlets mounted on the front edge or underside are awkward and inconvenient to use, and are often in the way of clamping work.

Outlet strips are really fancy extension cords. For most electrical tools, extension cords of a reasonable length are OK. However, as the amperage increases in the more powerful tools, it's best to carefully read the section of the owner's manual related to extension cords. Some electrical tools come with long power cords, and the additional length of an extension cord can lead to electrical problems. My belt sander is rated at 10.5 amps, 1,220 watts and has a 15' power cord, and it doesn't like extension cords. When I have used an extension cord, the

circuit breaker switches off after a few minutes of use.

It's always difficult, and maybe pointless, to state that one tool is more important or more useful than another. However, after working at the workbench for several hours, I always seem to end up with a tangle of power cords attached to various sanders, drills, plate joiners, heat guns and such. Then I use the battery-powered cordless drill. It's probably the most taken for granted, yet wonderful, power tool in the woodshop. The drills are available in a large variety of sizes, shapes, powers and colors. They are powerful enough to drive numerous drywall screws, and the battery can be recharged in less than 30 minutes. With a keyless chuck, it's quick and easy to change bits and drivers. The cordless drill could be the perfect tool for the woodworker, especially when at the workbench.



This shows a support piece that is hinged to the underside of the workbench top. When not in use, the support piece is secured to the underside of the benchtop via an attached block of wood that has a hole through it. A thin dowel is then inserted through the block and into the hole at the bottom of the support piece.

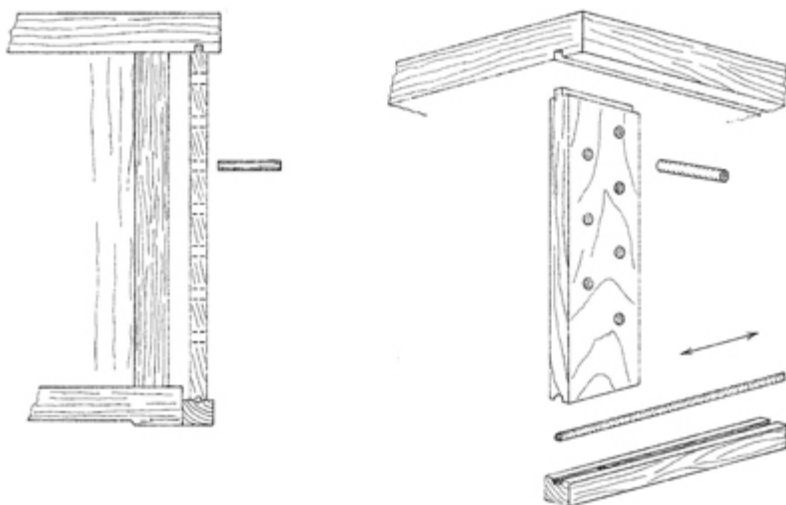
Choosing a Vise

Once again, tradition dictates a particular element of workbench design, namely that workbenches have at least two vises. Typically, the front vise is mounted on the left front, and the shoulder vise is mounted on the left edge. If you are left-handed (like me), reverse that pattern for the proper left-handed orientation.

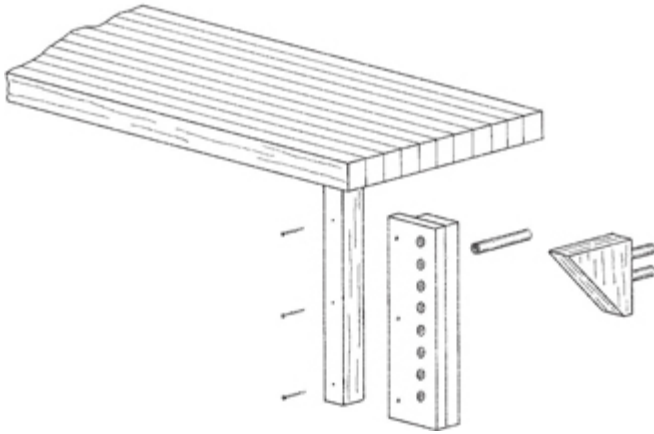
I believe it's important to pose these questions: Could vises be located at other workbench locations? Why not on the back corners or even the front center? Does a bench need a typical vise for the majority of woodworking functions? Are there manufactured and shop-made holding systems that could replace the standard vise? The answers are probably yes and no. First, it's very difficult to dismiss hundreds of years of workbench design. The modern vise is the evolutionary end product of thousands upon thousands of hours spent at a workbench. The result of this research and development is that Man is a clever creature, and innovations

are always just a blink of the eye away. Look in any tool catalog, current or historic, and there are hundreds of clamping and holding devices. Quite possibly, a few might work better for your applications than a standard vise.

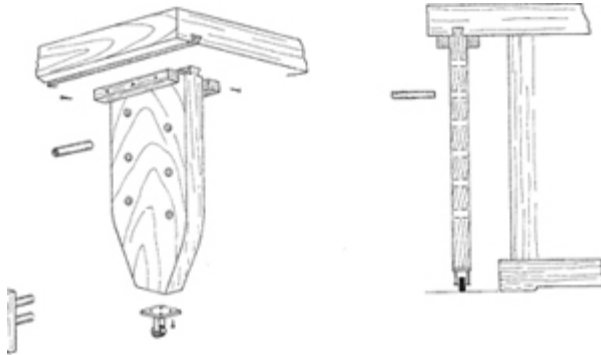
What you do want is the ability to firmly secure workpieces with a holding device that is quick and easy to operate. For example, the traditional vise with a long metal screw, approximately 1" diameter by 12", requires time and effort to turn the handle to open or close the vise. The option is a manufactured vise with a quick-release trigger. If the vise is open to its widest (approximately 14") and you need to close it, simply squeeze the trigger and slide the vise face to the closed position. This requires minimum effort and much less time than a traditional vise. If you feel that this comparison is unfair, I would suggest that you time yourself opening and closing both vise types ten times and see which you prefer.



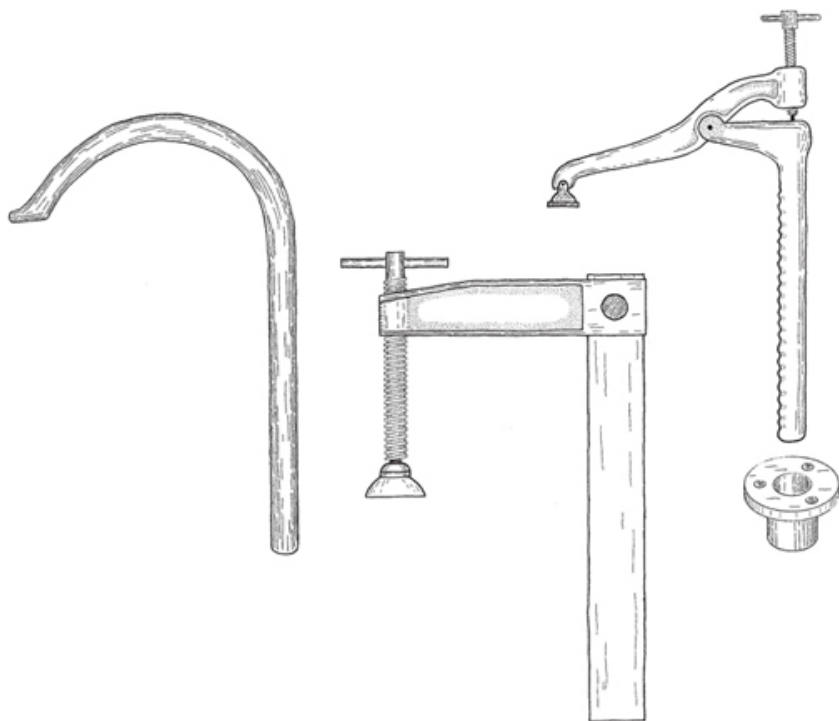
This drawing shows the details of the movable support. The support top has a tenon and slides in a groove on the underside of the benchtop. The support bottom has a halfround groove (cove cut) and slides on a metal rod that is attached to the frame piece. Use metal dowels in support pieces because wooden dowels can be broken by heavy workpieces.



This shows a simple support piece that attaches to the workbench leg. Two types of workpiece holders are shown: single dowel, and adjustable platform, which has two dowels for strength and rigidity.



Another design of a support piece has a reinforced dovetail fit to the underside of the workbench and a small roller (wheel) on the bottom. Extra braces at the top are necessary for minimizing “racking” motion.



Here are three types of bench hold-downs: two are adjustable for increasing and releasing your grip on the workpiece. The third is fastened and released using a mallet.

If you choose to use metal vises, be sure to attach wooden faces to the jaws. Often these vises don't close together perfectly, and so it's necessary to adjust the wooden faces with shims until the jaws are parallel when closed. Maintain vises by periodically tightening the mounting bolts, keeping the screw mechanism clean and free of debris, and once in a while adding a dab of grease to the mechanism.

Another useful accessory is created by attaching a hinged leg to the underside of the bench. This leg (1" by 3" by distance to floor) should have through-holes several inches apart into which a 1/2" metal rod is positioned. The rod then acts as a support for long boards clamped in the front vise. When not in use, the leg is returned to the underside of the bench and secured with a pin.

Other vise-type options worth considering for the workbench include:

- leg vises
- patternmaker's vise
- machinist's vise

- miter vises
- wedges
- bench holdfasts
- bench hooks
- toggle clamps
- band clamps
- rope



The movable support piece on the Charowsky workbench.

resources

This list is not meant to be encyclopedic. Rather than list every possible woodworking resource, I'm listing those that I have read, used, enjoyed, and feel comfortable recommending.

Magazines

Fine Woodworking

Taunton Press
63 S. Main St., P.O. Box 5506
Newtown, CT 06470-5506
800-283-7252
www.taunton.com/fw
fw@Taunton.com

Popular Woodworking Magazine

F&W Publications, Inc.
1507 Dana Ave.
Cincinnati, OH 45207
515-280-1721
www.popularwoodworking.com
popwood@fwpubs.com

WOOD Magazine

Better Homes and Gardens
P.O. Box 37471
Boone, IA 50037-4471
800-374-9663
www.woodmagazine.com
woodmail@woodmagazine.com

Woodshop News

35 Pratt St.
Essex, CT 06426
860-767-8227
www.woodshopnews.com
woodshopnews@worldnet.att.net

Woodsmith Magazine

2200 Grand Ave.
Des Moines, IA 50312
515-282-7000
www.woodsmith.com
woodsmith@woodsmith.com

Books

HOW-TO AND TECHNICAL INFORMATION

Build Your Own Mobile Power Tool Centers, John McPherson, Betterway Books 1995

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A Museum of Early American Tools

A Reverence for Wood

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www.woodturnerscatalog.com/index.html

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(power tools, machinery, accessories, general supplies)
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Organizations

American Association of Woodturners (AAW)
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651-484-9094
www.woodturner.org
aaw@mail.citilink.com

Early American Industries Association
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www.eaiainfo.org

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www.hardwood.org

International Wood Collector's Society (IWCS)

2300 W. Range Line Road

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www.woodcollectors.org

Mid-West Tool Collector's Association (M-WTCA)

Rte. 2, Box 152

Wartrace, TN 37183-9802

www.mwtca.org

National Woodcarver's Association

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One final reference: Use the Internet. Almost every company that makes tools and supplies has a Web site.

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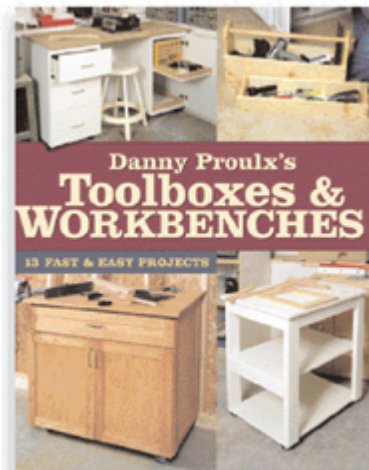
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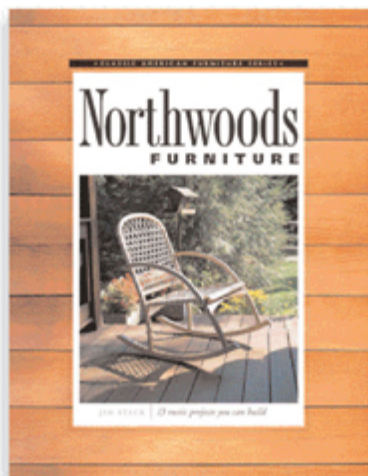
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